

# STUDY OF AIR CONDITIONING SYSTEMS FOR STORAGE AND DISPLAY OF ART WORKS

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## ABSTRACT

The article describes technical characteristics of modern air conditioning systems that are of use to ensure the ambient conditions required for storage and display of art works in art museums. The author performs comparison analysis of centralized and autonomous air conditioning systems. The article includes an inference about how important it is to combine elements of both systems according to the design tasks and features of the integrated museum and exhibition platform (Museum Quarter in Krasnoyarsk), which includes historical buildings and new modern exhibition areas.

**Keywords:** air conditioning, storage of art works, equipment for exhibition halls, art museum.

## INTRODUCTION

The main task of an art museum as an historical archive and modern culture center is storage of art works, which stands for keeping of museum funds and ensuring of adequate storage conditions for art works from other museums' collections in the case they are exhibited in the museum. Especially art works require the most complex system of storage conditions. Works of art that are created using different techniques and materials (painting, sculpture, handiwork) need special and unique parameters of the ambient environment, such as air temperature and humidity, degree of air flow circulation.

The V.I. Surikov Krasnoyarsk Art Museum in city is justifiably proud of its art works collection. Its funds possess paintings sector, including icon painting, sculptures from different materials (metal, wood, stone), handiwork (from ceramics and glass to fabric and fur). Collection of the Krasnoyarsk Art Museum comprises approximately 15.5 thousand artefacts. The museum also vigorously performs expositional activities. It does not only hold exhibitions from other museums, but also have recently started to perform vast inter-museum projects featuring both Siberian and major capital museums.

All these tasks oblige the Krasnoyarsk Art Museum to implement advanced storage conditions using required equipment. Lately, there was realized the *Museum Quarter* project, which is now a modern cultural life center located in the historic and art area of Krasnoyarsk city. The project implied adaptation of the historical building adjacent to the museum, located at the address 22 Parizhskoy Kommuny str. This project obliges the museum to meet its requirements for open and closed storing (display) and use of the latest technical means. Changes of air temperature and excessive or insufficient humidity adversely affect

paint pigments and a picture's basis, the primer. The same applies to metals, types of wood and stone used for sculpture. Artistic graphics has the strictest requirements for storage and display conditions. Air conditioning system is one of the main tools that help to create the required conditions, because it allows to adjust ambient factors in storage and display rooms efficiently. Adaptation of the building will initially allow to design and implement an optimal conditioning system to create the most convenient conditions for art works.

## RESEARCH METHODOLOGY

Comparative analysis of technique and technological capacities of two air conditioning system types is the method used in this study. The analysis implies detection and evaluation whether characteristics of every air conditioning system type conform to the museum needs, specifically, the needs of the V.I. Surikov Krasnoyarsk Art Museum to adapt the historical building located at 22 Parizhskoy Kommuny str., and create the *Museum Quarter* unified complex.

## SUMMARY OF RESULTS

Today, the issue of ensuring adequate storage and display conditions for art works is actively discussed, for museum collections face strong damage due to cut funds for high-quality equipment.

In-depth study of storage and display conditions for art works at the museum complex to be created is a topical issue, because the situation is specific and it requires creation of a unique concept and finding of individual solutions. Indeed, there is the number of publications considering the questions of climate control and ventilation from various aspects of museum activity. The following publications should be mentioned.

The researches X. Luo, Z. Gu, T. Li, X. Meng, T. Ma, C. Yu, Z. Wang [1, 2, 3] concluded that disregard to ecological control for artefacts and for disbalance in an air conditioning system are important reasons of damage to the artefacts kept in ethnographic and natural history museums. The scientists designed a testing hole with emitting panels to control ecological interfaces that allow to create stable conditions for long-term storing of excavated artefacts.

In the article named *Indoor air quality at five site museums of Yangtze River civilization* [4] the authors state that long-term storing of archaeological artefacts and historical ruins along the Yangtze River requires a certain quality of air in the premises of the five museums. During several months the scientists studied microclimate conditions in the premises and noticed instability and fluctuations of temperature and relative humidity, mass concentration of PM2.5 at high levels, permeation of gases and polluting air particles. The obtained results should raise serious anxiety at the museums of South China for all these factors are quite dangerous for their collections.

F. Ascione, L. Bellia, A. Capozzoli, F. Minichiello [5, 6] notice that strict heat hygrometry control in art museums and galleries is required primarily to keep art works properly and then to create a comfortable ambient for the visitors. The air conditioning system should constantly work performing good dynamic control of the microclimate. Funds can be saved by means of drying using adsorption, full energy recovering from deaeration, and changing of air output. X.J. Zhang, C.Y. Yu, S. Li, Y.M. Zheng, F. Xiao [7] also express their concern about air conditioning at the museum. According to them, large deviations of heat hygrometry parameters and airflow speed from the designed ones should be prevented at museums as they can damage art works. The researchers propose to use the THIC device, which

is cost-effective for cultural establishments can ensure independent temperature and humidity control.

The researchers D.A. Garcia, U. Di Matteo, F. Cumo [8] underline that choosing a technical system of museum conditioning, the state of the building and the landscape near the museum should be taken into account as not all heating systems may be suitable for them. In the article, the authors give guidelines on choosing the best heat system solutions for the certain historical building of the museum in the Northern Italy. A. Li, J. Xiong, L. Yao, L. Gou, W. Zhang [9] perform an alike study for the Shaanxi Historical Museum.

In their article, J. Ferdyn-Grygierek, A. Baranowski [10] present the analysis results of how different ventilation systems influence energy consumption in the museum building erected in 1929–1930. The simulation was performed with the use of *CONTAM* and *ESP-R* computer codes.

Reviewing of only several recent publications allows to say that the discussed issue is topical. However, the majority of them were mainly commercial. There were not enough analytics, comparison of possibilities, and qualitative tests carried out on the basis of other museums experience in them.

Air conditioning systems classification (hereafter referred as ACS): At the present time, all applied air conditioning systems are of two types – centralized and autonomous ACS. Each of these system types has advantages and disadvantages. Detailed analysis of these properties allows to define the conformity level to the needs of the V.I. Surikov Krasnoyarsk Art Museum with regard to the current issue of adapting the historical building located at 22 Parizhskoy Kommuny str., and create the *Museum Quarter* unified complex [14].

As the figure shows, this ACS type (Fig. 1) is a complex system of devices and mechanisms connected by air pipes.

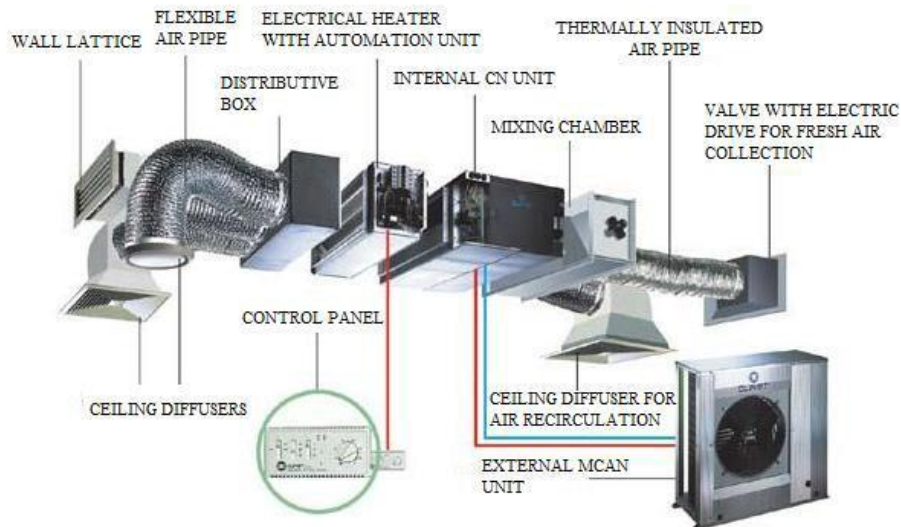


Fig. 1. Centralized ACS

The center of such ACS is a separate premise or even a building that contains ventilators performing air collection and circulation (pumping) through the rooms as well as withdrawal of used air. The same premise contains filters, an outdoor air cooler and heater that may be water that is supplied by the heating and plumbing systems, or by a cooling agent (conditioner) and electrical heater. To support the required humidity the system includes internal air humidifiers and driers. To save resources used air can be mixed with the fresh one if needed (recirculation), instead of taking all the air from outside. After that the

prepared air is delivered to rooms by a thermally insulated duct system. Control over the whole ACS system is carried by an automation unit receiving signals from temperature and humidity detectors. Withdrawal of used air is made by exhaust ventilation or, as it was mentioned above, it also can be used for recirculation. If a conditioner is used as a cooler, excessive heat is taken out through the external unit that should be placed in outdoor air or in the room with sufficient heat exchange ensured.

This air conditioning system is much simpler (Fig. 2).



Fig. 2. Autonomous ACSs

It requires only power supply to function. The system consists of separate units that are wall and ceiling coolers, placed in premises, and the external unit performing heat removal (should be placed as described in the previous paragraph). As it is said in press, one external unit can bear up to 16 coolers that is one unit allows to cool the air in 16 premises. The given ACS, also called split-system, cools and dries air.

It uses only the internal air. Automatic support of given temperature parameters is possible in every separate room if separate automation units are used.

The efficiency evaluation of each mentioned type application may allow to conduct **comparison** analysis of their technical and functional characteristics (Table 1)

Table 1. Comparison of technical and functional characteristics of centralized and autonomous air conditioning systems.

Characteristics	Centralized ACS	Autonomous ACS
Functions performed	Combines a full set of air preparation and a forced ventilation system to premises.	Features relative simplicity, portability, and does not include many units and elements.
Control of created conditions, parameters zoning.	Has one common center that allows to organize automatic adjustment and support parameters in all premises. At the same time, it does not allow to provide zoning (maintenance of individual atmospheric parameters) in separate rooms.	Allows to create microclimate in every separate room (parameters zoning) with the help of both automatic and manual control.
Fits in the museum interior.	For exhibition halls it is very important to prevent the interior from damage, which is why existing ventilation ducts in walls can be used for supplying of prepared air and collecting the used one.	Does not require any ducts. Does not require a separate room to place the equipment. Nevertheless, a disadvantage is that cooling units may not fit in the interiors of exhibition halls or even disturb their architectural concepts. It also concerns the external units that may disturb buildings exterior, which may be critical in some cases.
Flexibility of control in the case of malfunction.	In the case of malfunction or maintenance of even one of air	Malfunction or maintenance of a separate unit does not cause any change of

	preparation units all the system fails to function properly.	atmospheric parameters in other rooms. The system allows to replace or upgrade any of its elements with no influence on parameters of other elements.
Acoustic insulation	The preparation and transportation units are located in a separate premise where it is possible to create sufficient sound protection, so the ACS is noiseless.	Even the best of the split-systems are not noiseless.
Energy consumption	According to experts, these systems are more energy saving and cost efficient in maintenance.	Keeping and maintenance costs of autonomous ACSs for large premises are higher than of centralized.
Disadvantages of each system	<ul style="list-style-type: none"> <li>– the most difficult to install, bulky, includes a great number of complex and expensive elements, takes a lot of space to install air pipes;</li> <li>– in the case of malfunction or maintenance of even one air preparation unit, the ACS fails to function properly;</li> <li>– does not allow to provide zoning (maintenance of individual atmospheric parameters) in separate rooms.</li> </ul>	<ul style="list-style-type: none"> <li>– regulates and supports only one parameter which is air temperature, and, moreover, dries (dehumidifies) the air. Thus, to support the required microclimate air humidifying and air ventilation (at least natural one) systems should be used simultaneously;</li> <li>– cooling units do not fit in the interiors of exhibition halls, and may disturb their architectural concepts. The same concerns external units that may disturb buildings exterior (in some cases it is rather critical); <ul style="list-style-type: none"> <li>– even the best of split-systems are not noiseless;</li> </ul> </li> <li>– it is assumed that keeping and maintenance costs of autonomous ACSs for large premises are higher than of centralized ones.</li> </ul>

## CONCLUSION

To sum up abovementioned, it should be noted that none of the studied air conditioning systems possesses a comprehensive set of properties, which are completely adequate for the museum's needs to create microclimate in the to-be-adapted-building's rooms. Implementation of the centralized conditioning system will lead to useful space loss in the underground premises, because it will require installation of ventilation pipes under the ceiling of almost all rooms, moreover that will limit the usable space. Even though the architectural design for adaptation of the historical building for the museum is under development, it is obvious that the building will possess many relatively small rooms (about 40-50) which can be adapted for storage and exhibition halls. Implementation of a centralized ACS might imply difficulties in creation of even temperature and humidity ambience. The reason for that is that the rooms located in different parts of the building experience different influence of the outside environment (shadow or sunny side, wind direction, etc.) but supplied air is of the same parameters and it is impossible to vary its parameters in every separate room throughout the system.

This issue can be solved easily if autonomous air conditioning system is used, since every room is equipped with its own conditioner. At the same time,

the architectural concept of the design requires conformance of the interior, therefore the coolers should be concealed somehow. Additionally, there is a problem of placing external units on the building facade, since the institution for protection of cultural heritage prohibits this. Use of that system also requires installation of air humidifiers and ventilation system designing.

An interim option, which implies use of both systems, with the centralized ACS as the main one, meets the museum's needs well. At that, core decisions about the air conditioning system should be taken at the development stage of architectural concept and repair and restoration works designing. It is essential to include certain technical decisions about use of each systems in each room.

The V.I. Surikov Krasnoyarsk Art Museum has to meet the latest cutting-edge requirements to the system of art works storage and display. One of the main conditions for that is to equip the current rooms and being adapted ones with the adequate air conditioning system combining advantages of centralized and autonomous types. Implementation of the *Museum Quarter* project depends on this task directly, because only if the museum conforms to all required ambient parameters, it can become the center of Krasnoyarsk cultural life, which is truly modern and demanded for visitors and exhibition partners.

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