Evaluation of the climate in a new shared storage facility using passive climate control

Michael Højlund Rasmussen

Abstract

In 2003, The Centre for Preservation of Cultural Heritage in Vejle, Denmark opened and a new shared, storage building was taken into use. The owners of the shared storage are a group of 16 museums and archives. The climate is controlled by use of the concept of passive climatization. The building was made of modern building materials designed to yield a buffering effect against the fluctuations of humidity in the rooms. The humidity inside the storage rooms was expected to range from 45-60 % RH after a 3 year stabilisation period. Wireless radio data loggers were installed to monitor the climate.

Now after 3 years the climate has settled – but there is still a need for the dehumidifiers.

Another aspect of the storage facility is the administrative and practical running of the place. The whole concept of taking charge of the storage facilities has made the preservation efforts of the museums much easier. The users have been instructed in the correct use of the different facilities and they are themselves responsible for correct handling and placement of the objects. The conservation staffs play a supportive role, as consultants, assistants and tutors. The whole process of moving objects in, helping and tutoring the museum employees is an on-going process where good planning and some communication skills are needed.

Introduction

The Centre for Preservation of Cultural Heritage in Vejle is situated in the northern outskirts of Vejle, western Denmark, and consists of two institutions, Conservation Centre Vejle (established in 1975) and The Shared Storage Facility in Vejle (established in 2003). The two institutions are built together and thus form a physical unit. The Centre is a regional centre for the conservation and preservation of cultural property from seven historical museums in the former county of Vejle. After the abolition of the counties in Denmark in 2006 the institutions are now independent self-governing bodies under the control of two boards representing two different user groups. The seven historical museums constitute a main part of the user-group in both institutions, but for the Shared Storage Facility the user-group also encompasses three local art museums and a group of local archives.

This article will focus on the running of the shared storage facility and the results achieved up to now. Both technical and administrative aspects will be included, because both aspects are closely linked together in the process of running the institution. Occasionally the conservation centre is mentioned only to give an overall picture of the various roles played by the conservators working here.

The process leading to the decision for and planning of the Shared Storage Facility in Vejle is outlined in an article presented to the ICOM-CC triennial Meeting in The Hague [1].

Factors supporting the passive climatization

The Shared Storage Facility is constructed in a way that supports the concept of passive climatization. The idea that the construction and the physical properties of the building materials can contribute to establishing a stable climate on the basis of the outside climate has been discussed by several authors [e.g. 2 and 3]. Christoffersen has given a thorough account of the theoretical background on the use of these principles for the preservation of cultural heritage. In his thesis from 1995 the concept of passive climatization is referred to as the "Zephyr-concept" [2]. According to this the walls, floors and ceilings are constructed and dimensioned so that they will form a solid mass with a high thermal and hygroscopic capacity, good insulation capacity and no unwanted transportation of moisture. This is the same principle known from some older buildings such as churches and castles where the combination of mass and the hygroscopic properties of the materials are responsible for relatively slow fluctuations of temperature and humidity inside the building – which generally is considered a better alternative to no climatization at all.

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A stable and passive climate can be established at very low running costs if the building has a high degree of insulation and if the hygroscopic materials in the building can buffer the humidity – as necessary, in combination with a minimum of mechanical climatization such as supportive heating or dehumidification. Moreover, the use of materials and construction principles known from industrial buildings will also save money – a high priority in this case. It is assumed that the building is kept tight and closed and all human traffic and work in the stores is kept to an absolute minimum. This allows the air change rate to be kept low. The smallest interventions, such as the opening of doors and use of light for a longer period will have a destabilising effect on the interior climate of the building.

Description of the storage building

These ideas were adopted when building the storage facility. Finance was a key issue because the only way to persuade the responsible partners to accept the project was to offer something better for the same price as they would usually pay when leasing museum stores. There was also a demand for keeping down the running expenses as much as possible without jeopardizing the climate in the building. Hence the relative humidity (RH) was expected to be somewhere between 40 and 60 % with no more than +/- 5 % fluctuations per day. The temperature was expected to fluctuate in accordance with the outside climate between 7˚and 25˚ C. Provisions for keeping the stores free of frost were made by use of supportive heating in connection with the ventilation plant. In this way it was accepted that the RH and the temperature would fluctuate over a year, but only very slowly. Since the crucial parameter is the RH, it was important that the buffer capacity of the materials (as well as all the other measures taken) would ensure that the fluctuations of the RH would stay within the limits. The air change rate was estimated to be about one per day if the stores were kept air-tight and traffic reduced to a minimum.

The stores were built as 4 halls – in all 5432 m^2 of floorspace. In each hall, a mezzanine floor was established – covering ¾ of the ground space. A large corridor dividing the smaller halls from the 2 larger ones runs through the whole building. The stores and the conservation centre are connected by a building containing various facilities such as registration office, canteen, packing room, cold store and a freeze disinfection compartment (see plan fig. 1).

The storage building was constructed using lightweight concrete elements (1600 kg/m3 according to Danish Standard 420) with some moisture buffering capacity compared to solid concrete which has no fast acting buffering capacity. The walls were painted white with a cement based paint of high permeability (Skalcem 100 – Z (H_2O)-value <1). In order to store thermal energy, 250 mm of insulation (rock wool) was placed on the outside of the concrete walls. Corrugated steel plating protects the walls. The roof is a light construction consisting of concrete rafters with steel plating in between. On top of that there is a layer of 300 mm insulation material covered by double felted asphalt roofing. The roofs have a slight slope and both interior and exterior drains lead the water from the roof. The floor is made of concrete, insulated against moisture but without thermal insulation so that the ground heat can be exploited during the winter. For the same reason the floor serves as a cooling surface during the summer. The floor is painted with a grey epoxy paint in order to protect it against mechanical wear and the formation of dust. Moreover the surface facilitates easy cleaning and pest monitoring. The light is controlled by sensors so that the light is only on when someone is working in the stores.

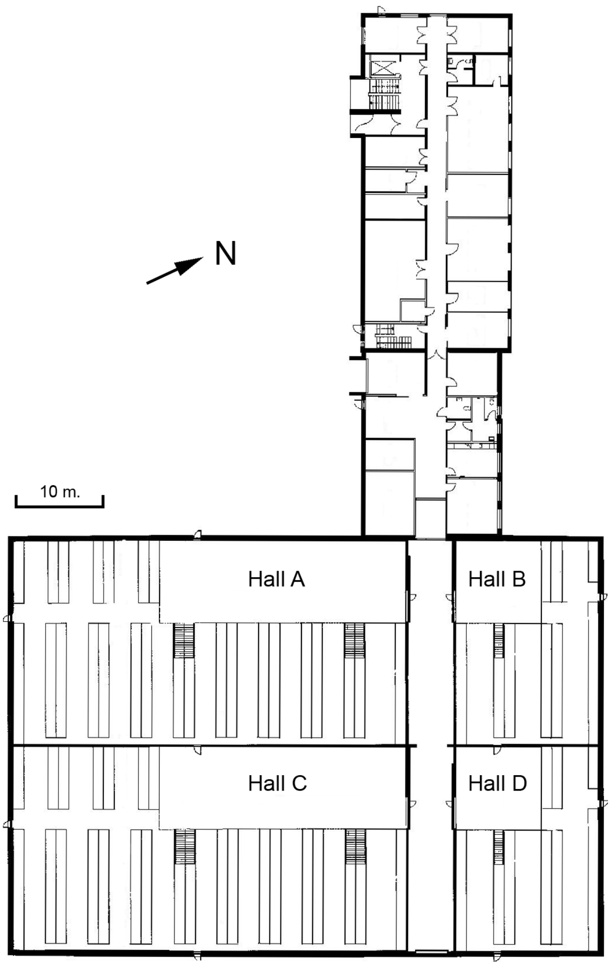

Figure 1. Plan of the Shared storage facilities: The stores (at the bottom) and the Conservation Centre (top). The building connecting the two institutions (middle) contains shared facilities.

In order to take out any surplus of moisture from the building process and to secure a stable RH at critical times during the year it was decided to install a supportive dehumidifying ventilation system. The ventilation system is connected to a dehumidifier and a heater for warming if the air goes below 8°C. The ventilation system is merely a system of tubes recirculating the air in the halls. The dehumidifier was set at 60% RH in the beginning of the period and later (September 2005) reduced to 50 % RH . One of the halls (B) has its own dehumidifier and circulation system and the climate here is adjusted for the preservation of archaeological metal objects – the RH is set at 40%.

The Shared Storage Facility was not equipped with a BMS (building management system). There are meters and loggers connected to nearly all power and heat consuming installations, but they are not connected directly to any central monitoring unit. That is why we had to carry out additional monitoring of the actual climate and power consumption in the stores. During the first one and a half years the climate was monitored by daily readings from a hand held digital hygrometer from Testo AG. These data are not shown here, but had the same linearity as is seen in the readings below. From March 2005 the climate has continuously been monitored by a number of radio data loggers from Hanwell Instruments Ltd (type ML2000). One logger is installed in each hall. Though the air change rate is low it must be expected that there will be a difference between RH and temperature near the floor and on the mezzanine. This difference is not suspected to play a major role because the air can circulate freely (due to the industrial gratings in the mezzanine floor) - but it will eventually be investigated.

The results – so far

Now, after 3 years of use it is time to evaluate if the storage facilities are working as intended. As can be seen from the graphs below (figs. 2 and 3) the indoor climate is rather stable. The relative humidity in all 4 halls is even and as expected the temperature follows the outdoor climate showing a slow fluctuation over the year. In wintertime the temperature is kept at 7-8°C by very limited heating of the recirculated air (in hall B the temperature is generally a bit higher due to a supplementary heating device). The RH does not fluctuate – the small fluctuations that can be seen are within the limits and they point to the fact that the dehumidifiers are functioning well. It is possible to see the cycles when the dehumidifiers start and stop. And it is very clear at which dates (for instance

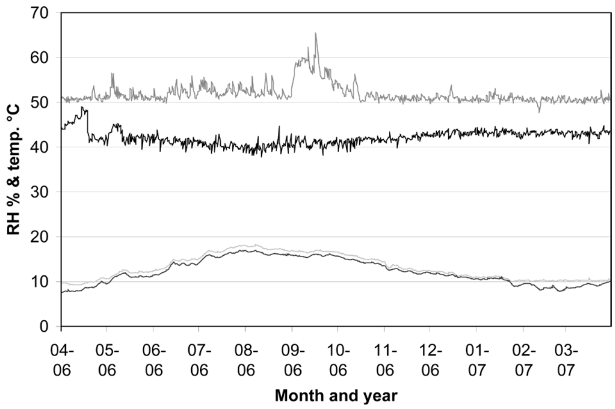

Figure 2. Halls C and B showing the two different climatic zones in the stores (hall C 50% RH (grey trace) and hall B 40% RH (black trace)). Hall C represents the other two halls A and D, since they are being dehumidified by the same plant.

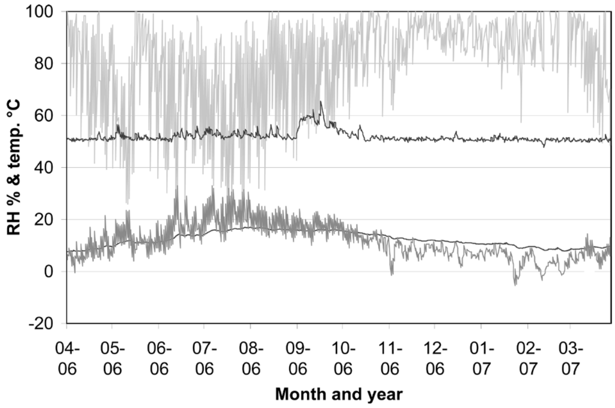

Figure 3. RH and temperature (black trace) in hall C and outdoors (grey trace) during 2006.

September 2006) the dehumidifiers have been shut down – mainly due to power failures. In that case the power failure caused a rise of 10% RH within 2 days. Having detected the failure and restored the power supply the RH was reduced to 50% after nearly 3 weeks.

In Fig. 3 the indoor and outdoor RH and temperatures are compared and the general picture is the same as seen in, for instance, the Regional Archive in Schleswig-Holstein – one of the few places where we have real data from a similar building based on passive climatization [3].

Some times it is possible to see if there have been many visitors or people working for several hours in the stores. This is generally the case when looking at hall A where one of the museums is working regularly with registration of the objects. In general the RH is slightly higher here than in the other stores (see fig. 4). On the other hand, hall A is full and has been so for the last year – the other stores are not yet filled – so one could expect a higher degree of buffering capacity offered by the most hygroscopic

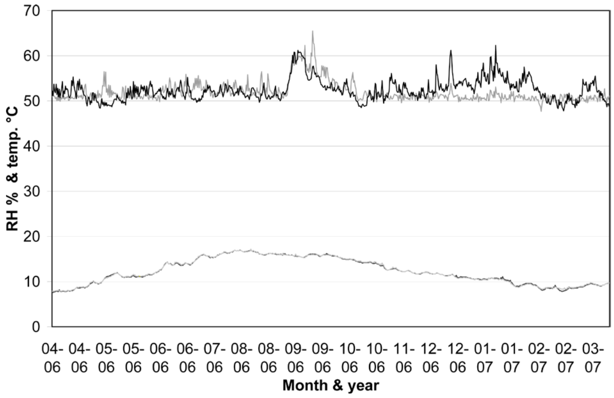

Figure 4. Comparison of halls A (black trace) and C (grey trace). Note the difference between the two RH graphs. The RH in Hall A fluctuates due to more human traffic in that specific store.

materials in the collection. The fact that the objects play a role as a climate buffer has been suggested by Padfield [3] – but it has not yet been investigated in this building, with its huge variety of objects (materials) in the collections.

The graphs, combined with information on the users' pattern of working suggests that people entering the stores for longer periods, or failures of the dehumidifiers, is the main reason for disturbances of the RH.

It is not possible to see from the data available if the building materials (in fact only the walls) offer any buffering of the RH as expected. From a theoretical point of view one could expect that the surrounding materials would play an active role when sudden changes in the RH take place. But since the dehumidifiers are running in frequent cycles it is difficult to determine how much of the moisture is being held back by the building materials and how much is taken up by the dehumidifiers. In future – as the user traffic decreases - we would like to look further into this problem.

Another way to understand the influence of the traffic on the climate of the building would be to measure the actual air change rate at times where there is no traffic – typically during weekends. We hope to be able to carry out such experiments in the future.

In order to get an idea of how much water is removed by dehumidification, it was decided to examine the dehumidifiers' power consumption. A measuring device (Merlin Gerin 10(63)A) was connected to the dehumidifiers, registering the cumulative consumption in kWh. Registration of the power consumption over a period of 9 months shows a relatively steady consumption (average of 477,5 kWh per week), which means that the dehumidifiers are working frequently. From the specifications of the Munters MLT 800 dehumidifiers we know that they are somewhat under dimensioned, which explains why it takes nearly 3 weeks to reduce the RH after the power failure in August 2006. According to information from climate engineer Lars D Christoffersen, Birch & Krogboe (2001), the dehumidifiers were only meant to take up moisture from the building process and to adjust the RH in the humid periods as a support for the buffering capacity of the building. After 3 years of constant dehumidification the power consumption/running frequency of the dehumidifiers indicates that they may serve as a more permanent solution than originally intended. We believe that the leakage is greater than expected due to much traffic and leaky escape doors in the stores. Because of the relatively low temperature the RH will increase when outside air leaks into the stores - especially during the summer period.

A simple calculation based on the average outside temperature and RH and the inside temperature indicates that the average temperature of the stores is very low and that only dehumidification, a certain amount of additional heat or a sufficient buffer capacity of the building (and the collections) will ensure an average RH of 50%. In other words, the stores are too cold if the climate should be completely passive. The same problem is described in connection with simulation studies on a similar storage facility in Ribe, Denmark by Padfield et al (4).

In our case however, we are quite satisfied with the fact that the objects are being kept at low temperatures because it reduces the risk of chemical and biological deterioration. In spite of the constant dehumidification the running expenses of the stores are still extremely low.

Administrative aspects of the running of the shared storage facility

The administrative construction of the Centre for the Preservation of Cultural Heritage in Vejle is a result of the development. The centre is divided into two "sub"-institutions with different funding. The conservation centre is funded by public finances and the shared storage facility is funded by a combination of public finances, funds and mortgage loans.

The Conservation Centre is run by the head of conservation, Lise Ræder Knudsen following the traditional leadership pattern of a public institution. The Shared Storage Facility on the other hand, is run by the users on the basis of self-service. On a daily basis the personnel of the conservation Centre function as caretakers and ensure that the climate is stable and that the technical installations are functioning. In future we hope to employ a caretaker to take over these responsibilities.

From the very beginning it was agreed that the museums should own the stores on a mutual basis in order to secure a common preservation standard of an acceptable level and to keep down the expenses. The area was shared out among the museums according to their wishes and they pay per square meter. It would have been preferable to split up the whole area into sections of different materials or particular types of objects but this idea was not favoured at the time when the planning took place. The only exception is hall B, which is reserved for keeping archaeological objects and the armour room in hall C – here the security is higher but the climate is the same.

The principle of self-service is only working because it was agreed to follow some strict rules from the beginning. The rules have been outlined in the User's Handbook, which is accepted by the assembly of the users. The conservators have written the handbook and they are constantly evaluating it in order to keep it updated. Since the opening in 2004 many regulations and procedures have been evaluated, changed or added. At the same time the museums representatives – the users and the conservation staff - have been in constant dialogue in order to raise the consciousness and the working standard of the users to an equal level suited for this specific building. It has been difficult really to make people understand the importance of keeping the climate stable by not working in the stores for longer periods and by not keeping the air lock wide open during transport in and out of the stores. These violations of accepted procedures do not seem serious to laymen but they can be read from the loggers and they disturb the climate.

Another thing that the users do not seem to have estimated correctly is the resources and time needed for moving in and recording the objects. Had they done this the whole project may not have come to anything, but right now it means that they have not yet completed the installation of their collections and this again means that the time where the climate could be expected to become stable is constantly postponed.

During the period since the opening of the storage facility the users have generally got used to the procedures and slowly developed a common consciousness of the importance of preservation principles. This has happened in a constant dialogue with the conservators, and in some cases it has even led to the development of new ways of improved storing procedures. Among the conservators, the cooperation with the users has also led to new and inspiring developments. For instance, a pest management programme has been inaugurated and now both users and the cleaning staff are much more aware of the occurrence of various pests in the stores.

A standard procedure is cleaning and freeze disinfection of the objects being moved into the stores. The users are very observant especially about the freeze disinfection procedure where not all objects can withstand the freezing. In this case the conservators are called in for advice.

A few procedures still need to be tightened up. For instance it is sometimes difficult to keep the aisles clear of objects or equipment – work always seems to be in progress. In some cases this will be allowed after consultation with the board – but generally the stores should be kept in order.

Conclusion

In general the climate of the stores is good – the RH is stable and the temperature follows the outside fluctuations on a slow and even curve as expected. The general level of conservation management at the museums and the quality of museum stores has improved considerably.

The RH and temperature graphs combined with the information on the users' pattern of working suggests that people entering the stores for longer periods or failures of the dehumidifiers are the main reasons for disturbances of the RH. Measurements of the actual air change rate will contribute to clarify this problem.

It is expected that the traffic and work in the stores will decrease in time, but we fear that the need for dehumidification will not decrease accordingly.

The main stabilizing factor of the passive climate is – until now – considered to be a combination of high thermal insulation capacity and dehumidification. We doubt the importance of the buffering capacity of the building (and the collection), because of the low temperature and the frequent dehumidification. If possible, it would be interesting to come to a better understanding of the interaction between these factors. Closer investigations of the microclimate of the Shared Storage Facility will hopefully take place in cooperation with the National Museum, Copenhagen and other partners.

The fact that the User's Manual was agreed on and issued before moving in has been a great achievement because it has allowed the conservators to play the role as caretakers without much authority but still able to act on irregularities. A constant dialogue on an equal basis between conservators and users is another important issue and a condition for a fruitful cooperation and a raised consciousness of preservation in general.

Author

Michael Højlund Rasmussen
Conservator, M.Sc.
Vejle Conservation Centre
Maribovej 10, DK-7100 Vejle
+45 76 62 11 55
mhr@konsv.dk

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