Cultural Heritage Science

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Managing Indoor Climate Risks in Museums

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Foreword

Just before the end of the second millennium, the Ministry of Education, Culture and Science launched the so-called Deltaplan to save the cultural heritage in the Netherlands. Extra finances were provided to the heritage institutes to improve documentation and preservation. Conservation treatment was considered the next step. The impact of the Deltaplan was enormous on a national scale. New repositories and museum galleries were built, and existing housing was upgraded to the highest standards of collection preservation. All collection rooms were equipped with mechanical improvements to upgrade air conditioning and air purification.

In those days, our Cultural Heritage Agency (RCE) issued for the first time a publication on *Passive Conservation: Climate and Light* in which the specifications for the museum indoor climate were provided. The recommended climate specifications were formulated based on the maximum achievable safety for highly moisture-sensitive materials and applied to all types of collection assuming implicitly that all objects were of equal value. Due to the application of these rather strict specifications, many historic buildings redesigned as museum buildings have been rigorously adapted to the needs of the moveable collection.

In later years it became more and more apparent from published research and non-published experiences worldwide that relative humidity fluctuations do not always lead to a high risk of mechanical damage; collections are better preserved at lower temperatures; financial aspects of climate control are becoming more and more important; and technological innovations make it possible to allow for a more sustainable approach in climate control.

The dissemination of this knowledge is of particular interest to us, since it is the mission of our agency to help heritage managers in the Netherlands and abroad to get the best out of our heritage and preserve it for a long period of time. I believe that my colleagues Bart Ankersmit and Marc Stappers have succeeded to realize this ambition by the nine-step decision model to manage climate risks presented in this book. They have been able to develop this model that will allow practitioners to use science to better face their challenges. With this book, I hope and expect that the Cultural Heritage Agency, acting at the heart of heritage management in the Netherlands, reaches out to many at home and abroad to manage their climate risks optimally so that generations after us can enjoy our heritage as we can today.

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Cees van't Veen

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We decided to add extra steps to cover human comfort, building needs and background information about building physics into the decision making process. In addition, the contents of the other steps were updated. We would like to express our appreciation and thanks to Lisje Schellen, Rick Kramer, Roman Kozlowski, Morten Rhyl Svendsen, Tom Strang, Marion Mecklenbrug and Shin Maekawa and many others for their help by reading drafts of (parts of) chapters, suggesting improvements and providing references. We also would like to thank Naomi Luxford for editing the manuscript and making valuable suggestions for improvements.

The publication was made possible with the financial support of the 'Sustainable Heritage' program and 'Shared Heritage' program of the Cultural Heritage Agency. We hope that this work will contribute to a more sustainable optimization of indoor climates in heritage institutes all over the world.

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Introduction

Abstract In this chapter the history of climate control is presented. Discussing the climate in an unheated museum in the late nineteenth century, to the extremely dry environment in a heated building in the early twentieth century. Experience with collection preservation during the Second World War indicated the positive effect of a stable relative humidity. Since the mid twentieth century the set point for the relative humidity and temperature closely followed the technical development of climate systems. Resulting in an uncontrolled increase in energy demand. The effect of these adaptations on the building and climate control systems was enormous. Confidence in the technology grew, all though in practice numerous examples exist of malfunctioning of these systems. The overall risks to the moveable collections have increased to an almost unacceptable level.

With this publication collection managers and stakeholders are assisted; by providing information that will allow responsible decisions about the museum's indoor climate to be made. The focus is not only on the outcome, but also on the equally important process, which leads to that outcome. Nine consecutive steps are proposed to structure the decision making: valuation, assessment of the collection needs, the building needs, human comfort requirements, preparing for a balanced decision, understanding the building physics, climate control strategies and finally a cost-benefit analysis to make a choice.

Keywords History of climate control • Decision making process

1.1 Introduction

This publication elaborates on different aspects of the decision making process when managing climate risks in museums and historic houses. The Dutch climate guidelines 'Klimaatwerk' (Ankersmit 2009) form the basis of this publication. At that time it was recognized that a large knowledge gap existed in the Dutch heritage field regarding how the indoor climate reacted with objects of cultural value. Additionally that stakeholders involved in the decision making process for climate control in heritage institutions were often opposing instead of collaborating parties. Most often, this 'fighting' process did not lead to a consensus in which the chosen climate control strategy respected both the needs of the building and those of the

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moveable collection. Many examples exist, not only in the Netherlands, of historic buildings that have been rigorously adapted to the needs of the moveable collection without considering the building fabric. It became very clear in 2008 that the dissemination of background information, to assist decision making for the optimal management of indoor climate risks, was an essential task for the Netherlands Institute for Cultural Heritage (ICN), now Cultural Heritage Agency of the Netherlands (RCE). As the Dutch publication has been used for 5 years and the decision making process field-tested in several (inter)national workshops, it is now possible to update the publication.

1.2 A Short History of Climate Control

Objects of great cultural value have always been collected, used and shown to a broad audience. Early museums and the houses of collectors would have been relatively humid and often unheated.

The National Museum in central Stockholm (Sweden) was built in 1860 and unheated until 1862. Concerns about the low temperatures were raised and floor heating was installed. The system, with hot water, which was only used during opening hours, was able to raise indoor temperatures up to 16 °C (60.8 °F) above outdoor temperatures. In 1902 complaints were made because winter temperatures in the ground floor galleries were around 10 °C (50 °F), while the restorers' workshop, in the attic, temperatures were as low as 0–6 °C (32–42.8 °F). As fire risks were considered too high, no stoves were allowed in the attic. Due to the large temperature differences between day and night time, condensation was a major risk to both building and collection. Condensing water was collected and channeled into large tanks. In one single night as much as 1000 l of condensed water could be collected inside the building (Legnér 2011). When in 1923 a new heating system with electrical stoves was installed, the temperature on the first floor could be raised to 18.5 °C (65.3 °F) in April, while in that same room in December 1922 the temperature had been −0.8 °C (30.6 °F). As a result, the relative humidity dropped to levels never before experienced by the collection (see Fig. 1.1 in which the orange arrow shows a relative humidity drop to approximately 20 %) resulting in clearly visible shrinkage of all wooden objects in that room. This forced an immediate shutdown of all heating. From this trial it became clear that room temperatures could be increased to human comfort levels, which encouraged the museum to satisfy the increasing numbers of visitors to the museum. A forced air ventilation system without humidification was installed in 1931 as the risk of mechanical damage was expected to be very low (the damage observed 10 years earlier was clearly forgotten). Unfortunately the Dutch collection of panel paintings cracked during the first winter and humidification needed to be added to the control system, which was implemented in 1932 (Legnér 2011).

One of the first museums to have a rudimental air conditioning system installed was the Boston Museum of Fine Arts in 1908. The air that fed into the exhibition

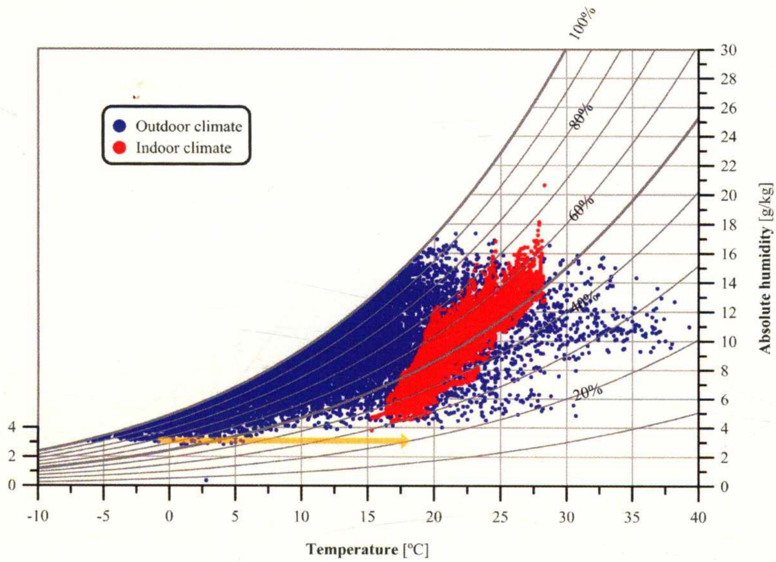

Fig. 1.1 Relative humidity, temperature, and calculated specific humidity outdoors (*blue data points*) between 2001 and 2005 in the Netherlands, and inside a heated historic interior without influencing the moisture balance over the period of January 2005–January 2006 (*red data points*) (Source: outdoor climate data from the Dutch National Institute for Public Health and the Environment – RIVM website, and indoor climate data registered every 30 min by The Cultural Heritage Agency). The *orange arrow* shows the resulting relative humidity drop due to heating in the National Museum Sweden from −0.8 to 18.5 °C (30.6–65.3 °F)

rooms was passed through a washer and humidifier, this way the relative humidity was maintained at 55–60 %. In the Cleveland Museum of Art dehumidification was considered, but found to be too expensive for the expected limited use during the two summer months per year (McCabe 2013). In 1934 a more elaborate system of 1740 lb of buffering canvas, spray humidifier and heater, with fans was supposed to maintain the relative humidity in the conservatory of Hampton Court Palace between 55 and 75 %, even though summer temperatures could be as high as 27 °C (80 °F) (MacIntyre 2013).

In 1935 the Gemeentemuseum in The Hague was opened. Berlage paid much attention, in his design to the technical equipment of the building, such as the natural and artificial lighting of the rooms. Since central heating was believed to be "an enemy of museums", three different heating methods were installed (Luciani 2013). Panel heating was chosen for the galleries of paintings. The system was based on warming structure surfaces with a large piping network circulating water at lower temperature than radiators and thus originating a comfortable direct uniform heat radiation. Radiating panels were placed on the ceilings, into the floors and into the walls, even if this was not a usual application at the time.

Steam radiators were installed in service and staff rooms, in the library, in the cabinets and in the rooms where ancient furniture and wooden objects were exhibited. Radiators were turned off during the night: "this interruption allows to obtain the cooling that is fundamental to prevent the drying of the woodworks". Humidifiers were in use in all the heated rooms and RH levels were measured by hygrometers to prevent damage. Finally in the conference room and in the entrance hall an air system was installed.

At the same period, the National Gallery in London employed a technician for some 8 months per year to deal with climatic damage such as cracking, blistering and flaking (Keeley and Rawlins 2013). When the Second World War broke out, plans were made to protect the collections in London from bombing and the additional risk of fire by relocating the collections to safer places. The collections of the V&A, British Museum, the National Portrait Gallery and about 30 other institutes were relocated in a quarry at Westwood, some 90 ft below ground. The walls were covered with a waterproof barrier and an air conditioning system to maintain the temperature between 15.6 °C (60 °F) and 24 °C (75 °F) and the relative humidity between 60 % and 65 %.

The 2000 paintings from the National Gallery were stored in the *Manod* quarry in Wales. The storage buildings were heated to 17 °C (63 °F) resulting in a stable relative humidity of 58 % for the rest of the war (Davies and Rawlins 2013). These stable conditions, proved very favorable to the sensitive collections. Upon their return to the museum an epidemic of blisters, cracks, and deformations broke out on the paintings as a result of poor climate conditions inside the museum building (Keeley and Rawlins 2013). Before the war, the scientific laboratory at the National Gallery had already investigated the moisture content of different species of wood in the exhibition gallery across the seasons. This determined that the yearly average equilibrium moisture content was 11 %, which corresponds to a relative humidity of 55–60 % (Keeley and Rawlins 2013).

It seems that by the 1940s climate control installations were more or less universally considered a required feature for museum collections. Air conditioning systems represented the state of the art and the favorable solution to engineers and conservators but still they involved problems which limited their spread, in particular high costs. The awareness that mechanical damage could be reduced by stable environmental conditions coincided with the technical developments of climate control systems. From the 1950s, systems became available which could influence the moisture balance in buildings, and disconnect to some extent, the indoor climate from the outdoor conditions (Brown and Rose 1996; Erhardt et al. 2007; Legnér 2011). Plenderleith rationalized the lowest acceptable and highest acceptable limit of relative humidity for museum galleries. He stated that, based on the 'seasoning' of wood, 50 % is the minimum value below which organic materials will be damaged by desiccation and 68 % is the absolute danger limit for mould at temperatures between 15.5 °C (60 °F) and 24 °C (75 °F) (Plenderleith and Werner 2013).

Central heating was introduced in the beginning of the twentieth century, but it only became commercially available for a wider public, including museums, from the 1950s. As a result uniformly heated spaces could be efficiently created. However, there was a downside effect during the heating season: the relative humidity

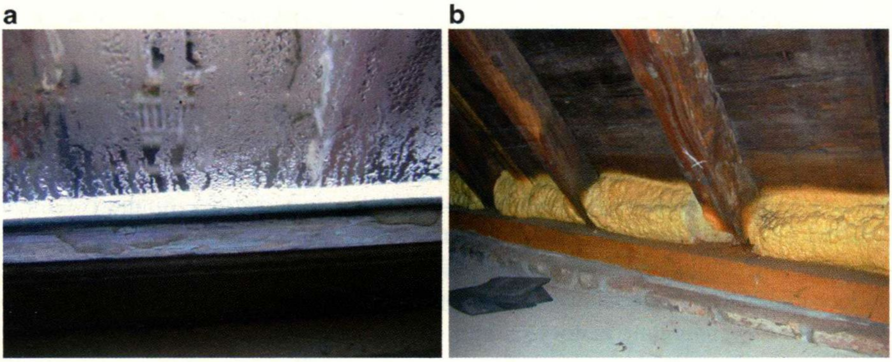

Fig. 1.2 Rotting of wooden window frames has been accelerated by condensation on single glass panes (**a**). Despite insulation, the wooden beam heads rot faster due to a combination of locally lower temperature and a subsequent locally increased relative humidity (**b**) (Photo: Hermans, Cultural Heritage Agency of the Netherlands)

decreased significantly, to much lower levels than museum collections were previously exposed (Maekawa et al. 2007). In order to reduce the risk of mechanical damage due to excessively low relative humidity, the air had to be moistened. Many museum collections, however, were housed in buildings that were not designed and built for this type of humidity and thermal control. Changing the humidity and temperature in these buildings required a number of structural adjustments. Therefore, reducing climate risks to the collection in this way often implied increasing the climate risks to the building. Humidified air condensed on cold surfaces in the building envelope that had previously remained dry, and wooden parts rotted at an accelerated pace (Fig. 1.2). So, the collection could be better preserved, but at the expense of the condition of the building fabric.

In the first edition of the well-known, extensively quoted but less critically read, publication *The Museum Environment* by Garry Thomson (1978), a relative humidity set point of 55 % with an acceptable fluctuation of plus or minus 5 % is proposed. The author adds, nevertheless, that:

> *We have a very uneven knowledge of how fast things in the museum change and what causes these changes, and yet we have to erect this framework of preventive conservation before rather than after our research has reached a dignified level of completion.* [. . .] *But the question of how constant relative humidity needs to be to ensure that no physical deterioration will occur at present remains unanswered. The standard specification of ±4 or ±5 % in relative humidity control is based more on what we can reasonably expect the equipment to do than on any deep knowledge of the effect of small variations on the exhibit.*

The value of 55 % was probably chosen as a London average. In 1986, Thomson published a second, updated edition of *The Museum Environment*. Two indoor climate classes were proposed: Class 1, with strict control (50 ± 5 %) or (55 ± 5 %) using HVAC systems for all national museums and all important new museum buildings and Class 2 (40 % < RH <70 %) using mobile (de)humidifiers (Thomson 1986).