Book of abstracts of the 14th International Conference on Indoor Air Quality in Heritage and Historic Environments

October 12, 2020 – October 16, 2020

Antwerp, Belgium

IAQ 2020

The University of Antwerp | Faculty of Design Sciences | ARCHES research group and conservation-restoration program organizes the 14th International Conference on Indoor Air Quality in Heritage and Historic Environments. The conference is a common forum for a fruitful discussion on the influence of the indoor air quality on historic objects. It is traditionally attended by a varied audience of conservators, curators, archaeologists, scientists, students and other stakeholders.

Scientific committee

Dario Camuffo, National Research Council - Institute of Atmospheric Sciences and Climate, Padua, Italy
Lorraine Gibson, University of Strathclyde, Glasgow, UK
Martina Griesser, Kunsthistorisches Museum, Vienna, Austria
Morten Ryhl Svendsen, The Royal Danish Academy of Fine Arts, Copenhagen, Denmark
Alexandra Schieweck, Fraunhofer Wilhelm-Klauditz-Institute WK, Braunschweig, Germany
Jiří Smolík, Institute of Chemical Process Fundamentals ASCR, Prague, Czech Republic
Matija Strlic, UCL Institute for Sustainable Heritage, London, UK
Jean Tétreault, Canadian Conservation Institute CCI, Ottawa, Canada
David Thickett, English Heritage, London, UK
Tomasz Sawoszczuk, Cracow University of Economics, Cracow, Poland

Organizing committee

Olivier Schalm, University of Antwerp, Conservation Studies
Willemien Anaf, University of Antwerp, Conservation Studies
Natalie Ortega, University of Antwerp, Conservation Studies
Kristel De Vis, University of Antwerp, Conservation Studies
Geert Van der Snickt, University of Antwerp, Conservation Studies
Elke Lingier, University of Antwerp

Sponsoring

We are grateful for the financial support of the University of Antwerp. The inspirational day was made possible with the financial contribution of the AIRCHECQ+ project, which is funded by the Belgian Federal Public Planning Service Science Policy (BELSPO) under project number BR/132/A6/AIRCHECQ.

Foreword

The original plan was to organize the IAQ2020 conference in Antwerp from March 31 to April 1, 2020. The conference room was booked, the location of the conference dinner was selected and we were quite proud on the splendid program. But suddenly, the first wave of the covid-19 virus came along. Travelling became impossible and social distancing was obliged. There was no other option than postpone the conference.

The period 12-16 October was originally selected in the hope that covid-19 would somehow be vanished by then. Unfortunately that appeared to be a fantasy. Worse, we are now confronted with a second covid-19 wave. For that reason, we have decided to organize the IAQ2020 conference as a virtual conference. This format is new to all of us, including for the organizers. Some of you will miss the physical contacts. Others even questioned the usefulness of a virtual conference. Unfortunately, reality does not give us another option and that damned virus will last for a while.

At the same time, we see some advantages in a virtual conference. We created an environment that allowed intensified communication among participants. We deliberately put the session of questions & answers after several presentations, not only as a kind of break but also as a way to give more time to the participants to formulate their questions. In addition, you will receive the book of abstracts in advance so that you can have a look at the topics of the speakers. We explicitly created a page with 'notes' after every abstract so that the book of abstracts becomes a workbook. The book of abstracts will be the only physical testimony of the IAQ2020 conference.

You play a crucial role in the memorability of the virtual IAQ2020 conference. The more active you are and the more you exchange ideas and pose questions, the better the conference will be. We will create an environment that makes that possible but it is your role to fill the blank 'Notes' pages as much as possible.

Olivier Schalm

Programme

Monday, October 12, 2020

14:00 – 14:30	Welcome Olivier Schalm
14:30 – 15:00	Trace Gas Measurements Inside a University Art Museum: Sources and Fate of Volatile Organic Compounds Joost De Gouw
15:00 – 15:15	Break – Publish your questions
15:15 – 15:30	Questions & Answers
15:30 – 15:45	Detection of VOCs in Smithsonian collections by Mass Spectrometry Alba Alvarez-Martin
15:45 – 16:00	APACHE project and management of museum microenvironments Ida Kraševec
16:00 – 16:15	When mould is a museum visitor Camilla Jul Bastholm
16:15 – 16:30	Break - Publish your questions
16:30 – 16:45	Questions & Answers
16:45 – 17:00	Air Quality in a historic submarine Imme Hüttmann
17:00 – 17:15	Multi scale modelling and monitoring for preventive conservation of museums objects – The EU-Horizon 2020 project SensMat Juergen Frick
17:15 – 17:30	Break - Publish your questions
17:30 – 17:45	Questions & Answers
17:45 – 18:00	Closing Words Olivier Schalm

Tuesday, October 13, 2020

13:45 – 14:00	Welcome Olivier Schalm
14:00 – 14:15	Indoor air quality monitoring using LoRa wireless sensor network: National Museum of Fine Arts, Cuba - a case study Lorenzo Hernandez-Tabares
14:15 – 14:30	Prototyping a LoRaWan Datalogger for ModeMuseum Antwerpen with Open Hardware and Software Dieter Suls
14:30 – 14:45	Break - Publish your questions
14:45 – 15:00	Questions & Answers
15:00 – 15:15	iAir - smart sensor array for indoor pollution monitoring: Model project for the development and application of an innovative multiparametric sensor solution for cost-effective and area-wide monitoring of pollutants Axel Solbach
15:15 – 15:30	Suicide Squad – Managing Emissions from Mixed Media Objects and Displays David Thickett
15:30 – 15:45	Break - Publish your questions
15:45 – 16:00	Questions & Answers
16:00 – 16:15	The BEMMA-Scheme helpful for low VOC inside display cases? Wolfgang Horn
16:15 – 16:30	eOddy – Application of an innovative multiparametric sensor for cost-effective detection of corrosive emissions from display materials Elise Spiegel
16:30 – 16:45	Break - Publish your questions
16:45 – 17:00	Questions & Answers
17:00 – 17:15	Oddy Testing and SPME GC-MS of Double-sided Pressure Sensitive Acrylic Adhesives and Compounds Used to Manufacture Acrylic Adhesives Catherine Stephens
17:15 – 17:30	Accelerated Corrosion Testing for Museums and Collections – Innovations and Standards in Pollution Control Alexandra Jeberien
17:30 – 17:45	Break - Publish your questions
18:00 – 18:00	Questions & Answers
18:00 – 18:15	Closing Words Olivier Schalm

Wednesday, October 14, 2020

13:45 – 14:00	Welcome Olivier Schalm
14:00 – 14:15	What's in the news? The micro-environment inside stacked paper Morten Ryhl-Svendsen
14:15 – 14:30	The impact of air motion on indoor microenvironments: passive ventilation strategies for historic bookshelves Morena Ferreira
14:30 – 14:45	Break - Publish your questions
14:45 – 15:00	Questions & Answers
15:00 – 15:15	Modeling the degradation of acidic, neutral and alkaline papers Jean Tétreault
15:15 – 15:30	Material research on the lead alloyed printing types and environmental mitigation actions in the Plantin-Moretus museum, Antwerp Patrick Storme and Werner van Hoof
15:30 – 15:45	Break - Publish your questions
15:45 – 16:00	Questions & Answers
16:00 – 16:15	Crizzling in Spanish Royal glasses, how to preserve them in historical buildings? Teresa Palomar
16:15 – 16:30	Application of thermoanalytical techniques to case studies in preventive conservation and novel conservation treatments Marianne Odlyha
16:30 – 16:45	Break - Publish your questions
16:45 – 17:00	Questions & Answers
17:00 – 17:45	Poster session – Questions & answers
17:45 – 18:00	Closing Words Olivier Schalm

Thursday, October 15, 2020

13:45 – 14:00	Welcome Olivier Schalm
14:00 – 15:00	Poster session – Questions & answers
15:00 – 15:15	Investigation of Fogging on Glass Display Cases at the Royal Ontario Museum Helen Coxon
15:15 – 15:30	Crystalline deposits in new display cases of the Rijksmuseum Jolanda van Iperen
15:30 – 15:45	Break - Publish your questions
15:45 – 16:00	Questions & Answers
16:00 – 16:15	Functionalized silica adsorbents for pollution reduction in cultural heritage environments Elyse Canosa
16:15 – 16:30	Climate Improvement for Paintings and Visitors in Affandi Museum, Indonesia Wolfgang Stumpf
16:30 – 16:45	Break - Publish your questions
16:45 – 17:00	Questions & Answers
17:00 – 17:15	Are our management actions good enough to preserve collections? Nuno Garcia Saraiva
17:15 – 17:30	How to Citizen scientists and indoor air quality Joseph Grau-Bove
17:30 – 17:45	Break - Publish your questions
17:45 – 18:00	Questions & Answers
18:00 – 18:15	Closing words

Posters

1	Measurement of Indoor air quality for cultural institutions with moderate resources Jennifer Sainato
2	Monitoring the environment surrounding Hasan's cloak: a case study Eva Menart
3	How environmental pollution affects modern paints: The influence of UV-light, sulfur dioxide and RH Laura Pagnin
4	Experiences with indoor generated air pollutants in the Weltmuseum Wien: The reinstallation of the collection as a chance to improve preventive measures? Sabine Stanek
5	Using oak (Quercus Sp.) as a natural, complex source of volatile organic compounds to study corrosion of lead metal in multi-year laboratory experiments James Crawford
6	Berardo Museum: a preliminary investigation of VOCs inside display case with contemporary painting Karen Barbosa
7	Pneumatic cleaning of books and manuscripts Ludmila Mašková
8	The National Museum of Brazil and the absence of national safety regulations for museums and its cultural goods: the tragedy Anny Falcão
9	Semi-quantitative GCMS-based thermal desorption to examine and limit the risk of volatile organic compounds to collections Kelli Stoneburner

Friday October 16, 2020

On top of the traditional IAQ conference, we propose an extra inspirational day for researchers who want to explore new research paths about indoor air quality and ways to improve it. The organizing committee has invited several local experts specialized in a variety of topics: human health, visual communication, design thinking to develop mitigation actions and the impact of architectural properties of buildings on mitigation actions. These topics are somehow related to your work and will hopefully inspire you for future projects. We intend to challenge you, to inspire you and hopefully to see you back in 2022 with new work.

13:45 – 14:00	Purpose of this day **Olivier Schalm**
14:00 – 14:20	Indoor air quality for heritage objects and human health: just a different interpretation of the same measurements? **Gustavo Carro**
14:20 – 15:00	Discussion
15:00 – 15:20	How to tackle complex problems such as improving the experience and preservation conditions in museum rooms using design thinking? **Kristof Vaes**
15:20 – 16:00	Discussion
16:00 – 16:20	Visual communication of complex science: from data cloud to graphic novel **Geert Potters**
16:20 – 17:00	Discussion
17:00 – 17:20	Alternative designs for the energy and climate needs of heritage objects and humans **Johan Van Rompaey**
17:20 – 18:00	Discussion
18:00 – 18:15	Closing words

Oral presentations

Trace Gas Measurements Inside a University Art Museum: Sources and Fate of Volatile Organic Compounds

J.A. de Gouw[1], D. Pagonis[1], D. Price[1], L. Algrim[1], Z. Finewax[1], J.L. Jimenez[1] and P.J. Ziemann[1]

1. *Department of Chemistry and Cooperative Institute for Research in Environmental Sciences, University of Colorado, Campus Box 216, Boulder, Colorado, 80309, USA*

Correspondence: *Joost.deGouw@Colorado.EDU*

Keywords: volatile organic compounds, surface loss, chemical reactions

We conducted a 6-week indoor air quality study at the University of Colorado Art Museum. Volatile organic compounds (VOCs), carbon dioxide (CO_2), ozone (O_3), nitric oxide (NO), nitrogen dioxide (NO_2), other trace gases and fine particles were measured continuously and with a fast time response. The measured concentrations of formic and acetic acid, NO_2, O_3, fine particles, sulfur dioxide (SO_2) and total VOCs were below the air quality standards for museums. Nevertheless, we obtained important insights into the processes that govern the composition of indoor air [1-3].

Total VOC levels in the Museum were found to be comparable to those found in polluted urban atmospheres albeit with a different composition [1]. While urban air is rich in hydrocarbons, the VOCs in the Museum contained many functionalized species including alcohols, ketones, and acids. VOCs were found to come from a range of sources, including people, outdoor air, and the use of cleaning products and wall paint. Using alternating measurements from a gallery and from a duct supplying air to the gallery, we could quantify VOC emission fluxes. The VOC fluxes from people compared well with those from previous measurements in a classroom [2].

The loss of VOCs to building surfaces could be seen from the varying fraction of VOCs that was recirculated by the HVAC system. It was found that surface loss was a major sink for VOCs with saturation vapor concentrations of $<10^8$ $\mu g\ m^{-3}$ and Henry's Law solubility constants of $>10^2$ $M\ atm^{-1}$ [2]. To further explain these findings, we studied the absorptive uptake of VOCs on painted surfaces in the laboratory.

We quantified ozone loss rates in the museum and found that reactions with surfaces, occupants, NO and NO_2 were all important [2]. Aside from air exchange and surface uptake, some highly reactive VOCs were found to undergo autoxidative reactions [3]. Specifically, we observed the formation of highly oxidized molecules (HOMs) and particulate matter from the oxidation of limonene released from an orange.

We combined the insights from the indoor studies to build a model that allows the levels of pollutants to be predicted based on ambient concentrations and air exchange rates. Finally, we will present results from other indoor studies and discuss the relation between indoor and ambient air in more detail.

References

[1] D.J. Price, D.A. Day, D. Pagonis, H. Stark, L.B. Algrim, A. Handschy, S. Liu, J.E. Krechmer, S.L. Miller, J.F. Hunter, J.A. de Gouw, P.J. Ziemann, J.L. Jimenez, Environ. Sci. Technol., 53 (2019), 13053-13063.

[2] D. Pagonis, D.J. Price, L.B. Algrim, D.A. Day, A. Handschy, H. Stark, S.L. Miller, J.A. de Gouw, J.L. Jimenez, P.J. Ziemann, P. J., Environ. Sci. Technol., 53 (2019), 4794–4802.

[3] D. Pagonis, L.B. Algrim, D.J. Price, D.A. Day, A. Handschy, H. Stark, S.L. Miller, J.A. de Gouw, J.L. Jimenez, P.J. Ziemann, Environ. Sci. Technol. Lett., 6 (2019), 520–524

Notes:

Detection of VOCs in Smithsonian collections by Mass Spectrometry

A. Alvarez-Martin[1], S. Heald[2], E. Kaplan[2], K. McHugh[2], C. Martin[2], J. John[3], M. Wilcop[4], R. Barden[4], R. Anderson[4], G. A. Newsome[1], R. Kaczkowski[1] and G. M. Kavich[1]

1. *Museum Conservation Institute, Smithsonian Institution. 4210 Silver Hill Rd., Suitland, MD. United States of America*
2. *The National Museum of the American Indian. Smithsonian Institution. Independence Ave SW, Washington, DC, United States of America*
3. *The National Museum of the American Indian. Smithsonian Institution. 1 Bowling Green, New York, NY, United States of America*
4. *The National Museum of American History, Smithsonian Institution, 1300 Constitution Ave NW, Washington, DC, United States of America*

Correspondence: *alba.alvarez@usal.es*

Keywords: volatile organic compounds, gas chromatography mass spectrometry, direct analysis in real time mass spectrometry, degradation of collections.

Some volatile organic compounds (VOCs), generated and accumulated in exhibition cases, are capable of inducing degradation in historical artifacts [1]. In order to avoid deterioration of museum collections, the Museum Conservation Institute (Smithsonian Institution, Washington, DC) has optimized and implemented two non-destructive methods for mass spectrometry analysis with the aim to evaluate a wide range of these VOCs.

Solid phase micro-extraction (SPME) [2] coupled to gas chromatography mass spectrometry (GC-MS) and direct analysis in real time mass spectrometry (DART-MS) have been used for several case studies at three Smithsonian museums: National Museum of American History (Washington), National Museum of the American Indian (New York city) and National Museum of the American Indian (Washington).

The results describe the different methodologies carried out in order to develop a systematic and reproducible sampling protocol, where the setup does not require any modification and the sampling remained nearly invisible and unobtrusive to museum visitors and staff.

Furthermore, these sampling methodologies have been optimized to enable transportation of the SPME fibers between the museum and the laboratory, making this technique more accessible for small museums that may not be equipped with mass spectrometry instrumentation.

These aspects, in combination with the fast analysis that this technique brings, allow museum staff to take a prompt response in order to mitigate VOCs accumulation.

References

[1] P.B. Hatchfield, Pollutants in the museum environment, Archetype Publications Ltd., London, 2002.

[2] J.B. Pawliszyn, Method and device for solid phase microextraction and desorption, in: U. Waterloo (Ed.), Canada, 1990.

Notes:

APACHE project and management of museum microenvironments

I. Kraševec[1], E.Menart[2,3], I. Kralj Cigić[1], M. Strlič[1], J. Markelj[1], J. Grau-Bove[4], H. Cooray[4], M. Anders[5], S. Ziemann[5] and P. Baglioni[6]

1. *University of Ljubljana, Faculty of Chemistry and Chemical Technology, Večna pot 113, Ljubljana, Slovenia*
2. *National Museum of Slovenia, Prešernova cesta 20, Ljubljana, Slovenia.*
3. *Jožef Stefan Institute, Jamova cesta 39, Ljubljana, Slovenia.*
4. *University College London, Institute for Sustainable Heritage, 14 Upper Woburn Place, London, UK.*
5. *Zentrum für Bucherhaltung, Bücherstraße 1, Leipzig, Germany.*
6. *University of Florence, CSGI, Via della Lastruccia 3-12, Florence, Italy.*

Correspondence: *ida.krasevec@fkkt.uni-lj.si*

Keywords: APACHE, monitoring, pollutants, museum, gallery

Within the EU Horizon 2020 project APACHE, the aim is to develop innovative solutions for management of museum microenvironments. This will be achieved using multi-scale modelling of environments and prediction of degradation, by developing a new generation of active and intelligent storage enclosures and display cases, and devising collaborative decision-making tools to facilitate preventive measures. New enclosure materials, pollutant absorbers and materials for passive regulation of temperature and humidity will be developed along with sensors and software tools, with the aim to reduce costs, specifically in small and medium institutions where budgets for preventive conservation might be modest.

To develop an understanding of the status quo in partner institutions, a comprehensive monitoring plan was developed, aiming to compare seasonal measurements both inside and outside object enclosures and display cases, of pollutants, such as NO_2, SO_2, acetic acid, formic acid, formaldehyde, acetaldehyde, ozone and H_2S. Commercially available methods will be used, except for the acidic pollutants, where a new method using a commercially available passive sampler was developed and validated. In addition, the plan will include continuous monitoring of T and RH. Using the collected data, the quality of microenvironments will be assessed and development of models enabled.

APACHE (2019-2023) stands for "Active & intelligent PAckaging materials and display cases as a tool for preventive conservation of Cultural Heritage" and has 26 partners from EU countries, Brazil and USA.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814496.

Notes:

When mould is a museum visitor

Camilla Jul Bastholm[1], Birgitte Andersen[2] and Jane Richter[1]

1. *KADK The Royal Academy of Fine Arts School of Architecture, Design and Conservation, Philip De Langes Allé 10, 1435 Copenhagen, Denmark*
2. *Technical University of Denmark, DTU Bioengineering, Department of Biotechnology and Biomedicine, Søltofts Plads, Building 221, 2800 Kgs. Lyngby, Denmark*

Correspondence: *cjb@kadk.dk*

Keywords: Museum repositories, mould, fungal growth, exposure, occupational health

In the last decade, fungal infestations have become an increasing problem in many Danish museum repositories challenging the indoor air quality. The fungal growth is unexpected, since the relative humidity (RH) in most Danish museums, is controlled by HVAC systems, fluctuating between 40 – 60 % RH. Fungal growth deteriorates materials and threatens the preservation of heritage collections [1], as well as the health of staff and visitors. When a heritage collection poses a health hazard, the accessibility is reduced, and the value for research and dissemination is diminished. These are the main reasons why fungal growth in museum repositories is devastating, and targeting preventive conservation to avoid fungal growth is essential.

A great deal of controversy surrounds the topic of fungal exposure and health, mainly due to the ambiguous nature of fungal allergy and the uncertainties of the immunological response [2]. Limit-values does not exist and the symptoms of fungal exposure depend on the individual exposed. There is a lack of studies examining the indoor air quality in museum repositories regarding fungal exposure. Museum-staff has insufficient knowledge of the risk, which complicates everyday decisions on occupational health and work-life safety in museums and museum repositories.

When fungal infested repositories are examined, the dominating methods are surface sampling followed by morphological or molecular identification, as in the study of domestic environments [3]. In housing though, fungal growth is primarily caused by damp indoor environments or water damages, which is a very different premise than climate-controlled museum repositories. A new approach to the examination of repositories, may provide a more comprehensive understanding of the causative factors to the fungal occurrence and a more targeted prevention.

This Ph.D.-project (ongoing, by C.J. Bastholm) examines fungal infestations inside Danish climate-controlled museum repositories. The aim is to gain knowledge, that may qualify decision making to ensure the preservation of cultural heritage as well as the health and safety of museum staff. The project has focus on three research objectives:

Characterization of fungi in museum repositories, examines the indoor fungal composition in Danish museum repositories, and a potential correlation between fungal species and materials of cultural heritage. The aim is to gain knowledge about the fungal infestations, in order to provide a more targeted prevention and ensure the preservation of cultural heritage.

Fungal growth in museum repositories and human exposure examines if the level of airborne fungi differs, when museum staff are handling artefacts during three specified work situations. The aim is to qualify decision making in occupational health to comply with labour safety legislation.

A new approach to examination of fungi in museum repositories examines if different sampling and analyzing methods used in museum repositories will give the same results. The aim is to asses if a new approach will provide a more comprehensive fungal mapping and a more targeted prevention.

The Ph.D.-project is ongoing (2017-2021) and preliminary results, primarily with focus on fungal exposure in museum repositories, will be presented.

References

[1] Sterflinger, K. and Piñar, G. (2013) Microbial deterioration of cultural heritage and works of art — tilting at windmills? Applied Microbiology and Biotechnology, vol. 97(22), pp. 9637–9646.

[2] Rudert, A., Portnoy, J., (2017). Mold allergy: is it real and what do we do about it? Expert Review of Clinical Immunology, vol. 13(8), pp. 823–835

[3] Sanmartín, P., Dearaujo, A., Vasanthakumar, A., (2018). Melding the Old with the New: Trends in Methods Used to Identify, Monitor, and Control Microorganisms on Cultural Heritage Materials. Microbial Ecology, vol. 76(1) pp. 64-80.

Notes:

Air Quality in a Historic Submarine

I. Hüttmann[1], T. Matsui[2], W. Luo[3] and K. McWhirter [3]

1. *Oregon Museum of Science and Industry (1945 SE Water Ave. Portland, OR, USA)*
2. *World Heritage Studies Program, University of Tsukuba, Japan*
3. *Department of Civil and Environmental Engineering and Department of Chemistry, Portland State University, USA*

Correspondence: *ihuttmann@omsi.edu*

Keywords: submarine, gaseous pollutants, measuring sytems

The USS Blueback (SS-581) is the last diesel-electric submarine to join the United States Navy, and operated from 1959 to 1990. The Oregon Museum of Science and Industry (OMSI) currently hosts the USS Blueback, conducting educational tours and events on a regular basis. The submarine, which is listed in the National Register of Historic Places, has been witness to a number of important historical events and is itself of great historical importance. Displayed objects reflect this history: the submarine exhibits uniforms, notebooks, utensils, medals, and even food items.

Because the USS Blueback represents an unconventional museum space, an air quality study was carried out to determine environmental preservation conditions. Air quality was measured using Kitagawa precision gas detector tubes and GC-MS with a modified TO-17 method. Measurements were carried out in the crew kitchen, the engine room, outside of the submarine, and in the museum hall.

Preliminary results indicate the presence of ammonia, organic acids, formaldehyde, hydrocarbons, and CFCs, probably used for cooling air in the submarine. Conservation strategies will be determined following the analysis of the determined gaseous compounds.

This study presents the question of museum air quality in unconventional spaces, especially those of a military nature. Military equipment oftentimes has historical value, and it is not atypical for it to be conserved. However, military equipment also presents the challenge of new materials and substances not found in standard museum environments.

Notes:

Multi scale modelling and monitoring for preventive conservation of museums objects – The EU-Horizon 2020 project SensMat

J. Frick[1] , S. Gambarelli[1], J. Zöldföldi[1], B. Hejazi[1], P. Gänz[2], S. Simon[2], R. Dotoli[3] and M. Scarpa[4]

1. *Materials Testing Institute University of Stuttgart, Germany*
2. *Institute for Parallel and Distributed Systems, University of Stuttgart, Germany*
3. *CETMA, Technologies Design and Materials European Research Centre, Brindisi, Italy*
4. *Iuav University of Venice, Italy*

Correspondence: *juergen.frick@mpa.uni-stuttgart.de*

Keywords: Multi-scale materials and evironmental monitoring, advanced monitoring, preventive conservation

SensMat [1] aims to develop and implement effective, low cost, eco-innovative and user-friendly sensors, models and decision-making tools, as well as recommendations and guidelines to enable prediction and prevention of degradation of artefacts as a function of environmental conditions. Multi scale materials and environmental modelling will be used to develop deterioration models in certain environments and validate the developed tools. An Integrated Software Framework will use the data as input to generate indicators specifically designed to support Cultural Heritage professionals and operators. The presentation will give an overview on the methodology and first results of the project.

References

[1] EU-Horizon 2020 project SensMat - Preventive solutions for Sensitive Materials of Cultural Heritage, Grant Agreement No. 814596. www.sensmat.eu

Notes:

Indoor air quality monitoring using LoRa wireless sensor network: National Museum of Fine Arts, Cuba - a case study

A. Cabal[1,2], L. Hernandez-Tabares[2] , F. Canovas-Borges[3] , A. Garcia-Blanco[3], O.J. Antuna-Benitez[3] and P. Van Espen [1]

1. *University of Antwerp, Faculty of Sciences, Department of Chemistry, AXES research group, Groenenborgerlaan 171, 2020 Antwerp, Belgium*
2. *Center of Applied Technologies and Nuclear Development (CEADEN), Calle 30 #502, 11300 Havana, Cuba*
3. *National Museum of Fine Arts, Trocadero y I.Agramonte, CP10200, Havana, Cuba*

Correspondence: *lorenzo@ceaden.edu.cu*

Keywords: indoor air quality, museum, heritage, wireless, LoRa

The National Museum of Fine Arts in Havana, Cuba, exhibits both Cuban and International paintings and sculptures, along with a collection of ancient art. The tropical conditions as high temperature and high relative humidity are not suitable at all for holding and preserving the collections. Furthermore the museum is located in one of the most polluted air zones of the city of Havana. For that reason it was necessary to measure the museum´s indoor air quality in order to evaluate the risks and to adopt the appropriate mitigation actions. Physical parameters as temperature, relative humidity, light intensity and airborne particle size were measured in several museum´s places like storage rooms, exhibition halls, etc. The measurements were done by deploying a wireless sensor network, built from scratch, based on Arduino protoboards, digital sensors and LoRa radio modules. The results of the measurements made in different campaigns, their interpretation and the proposed measures to improve air quality are shown.

Notes:

Prototyping a LoRaWan Datalogger for ModeMuseum Antwerpen with Open Hardware and Software

Dieter Suls[1] and Regan Watts[2]

1. *ModeMuseum Antwerpen, Nationalestraat 28, 2000 Antwerpen (Belgium)*
2. *Product Development, University of Antwerp*

Correspondence: *dieter.suls@momu.be*

Keywords: Open Hardware, Open Software, LoRaWan, Museums, Climate Control

The heritage sector is getting more and more acquainted with terms like Open Data and Open Source Software, but there is also a concept such as that of Open Hardware that is worth examining. Open Hardware can be described as: *'Physical artifacts of technology designed and offered by the Open Design Movement. Both Free and Open Source Software (FOSS) and Open Hardware are created by this Open Source Culture movement and apply a like concept to a variety of components'* (Source: Wikipedia).

Open Hardware is released under an open license and its design (i.e. drawings, schematics, circuit layout, etc.) is well-documented and transparent. This allows collectively sharing, improving, discussing, tinkering of the hardware and building further on the results of others. Probably the best known examples of Open Hardware are the Arduino (an open source electronic prototyping platform) and the Raspberry Pi (a fully operational single-board computer that has the size of a credit card.). There is a vivid ecosystem of Open Hardware developers, Open Software libraries, sensors and other components, numerous well-documented DIY-projects going from super computers to robots and domotica, etc.

Since a few years, Antwerp's Fashion Museum, MoMu, has been advocating an Open Data policy, resulting in a strategy for making its content available as openly as possible and experimenting with and implementing Open Source Software packages (e.g. Koha (Library System), Resourcespace (Digital Asset Management System), Omeka-S, etc.). We try to extend this Open Data philosophy also to our hardware and started experimenting with Arduinos and Raspberry Pis to build some prototypes.

One of the use cases we focused on was the development of a datalogger for tracking climate conditions in an external storage. We wanted to use Open Hardware components, Open Source Software and apply an Internet of Things-philosophy. The datalogger had to track temperature, humidity, lighting conditions and enable pest control. Data from the datalogger had to be accessible from an external location, include geotags and had to be open and re-useable in other museum applications.

This presentation elaborates on how we managed to make different prototypes, using LoRaWan as communication technology in order to realize this use case, and how we will scale things up, together with the Department Product Design of the University of Antwerp, into a functioning system that will be used by MoMu for monitoring its (external) storage facility.

Notes:

iAir - smart sensor array for indoor pollution monitoring: Model project for the development and application of an innovative multiparametric sensor solution for cost-effective and area-wide monitoring of pollutants

E. Spiegel[1], A. Solbach[2] and A. Hahn [2]

1. *Care for Art, Maximilianstraße 31, D-80539 München, Germany*
2. *BioChip Systems, Maximilianstraße 47, D-80539 München, Germany*

Correspondence: *e.spiegel@care-for-art.de*

Keywords: VOC, multiparametric, sensor, preventive conservation (maximum 5)

A well-known, serious problem in museums – particularly in showcases – is the exposure to pollutants and the resulting damage to art and cultural heritage due to unsuitable display and storage materials. Preventive protection of the objects against undesirable effects can only be achieved by early and targeted detection of the pollutants. [1] Consequently, this means that an object-specific and systematic monitoring of the objects in the exhibition showcases or at enclosed storage locations is necessary. However, the fact that there are currently no suitable simple and inexpensive detection methods for the relevant pollutants proves to be a challenge.

The focus of the present work is a project funded by the Deutsche Bundesstiftung Umwelt (DBU) entitled "iAir - Lab-on-Chip VOC Sensors". The objective of the project is the development of an innovative multiparametric "Smart-Sense" application - iAir. The main focus of the iAir sensor system is the continuous measurement of the pollutant load by "volatile organic compounds" (VOC) in museum showcases, storage boxes and exhibition rooms. The research focuses primarily on organic acids (acetic acid and formic acid) and aldehydes (formaldehyde and acetaldehyde), which are regarded as "key pollutants" for art and cultural assets. [3]

Compared to the currently available and applied methods for the avoidance of pollutants, the aim is to create a significantly more cost-effective, faster and suitable solution for the requirements of museums. Key is the combination of commercially available air quality sensors with additional sensor elements. The presentation summarizes the status quo of the iAir-project, which pursues the following objectives:

a) Reference measurements with existing technology
b) Requirements/definition of the design of the new sensor from a museum point of view
c) First results from laboratory and field measurements with the iAir prototype

References

[1] E. Spiegel, Emissionen im Museum - Ein Gütezeichen für Ausstellungsmaterialien und Vitrinen als mögliches Instrument zur Schadstoffbegrenzung, Eul Verlag, Lohmar– Köln (2012).

[2] „iAir – Lab-on-Chip VOC-Sensorik“ Modellprojekt zur Entwicklung und modellhaften Anwendung einer innovativen multiparametrischen Sensoriklösung für eine kostengünstige und flächendeckende Überwachung der durch anthropogene Umwelteinflüsse hervorgerufene VOC-Belastung von national wertvollem Kulturgut“

[3] J. Tétreault, Airborne Pollutants in Museums, Galleries and Archives, Risk Assesment, Control Strategies and Preservation Management. Canadian Conservation Institute, Ottawa (2003) p. 33.

Notes:

Suicide Squad – Managing Emissions from Mixed Media Objects and Displays

D. Thickett[1]

1. *English Heritage, Rangers House, Chesterfield Walk, London, SE108QX, UK*

Correspondence: *David.thickett@english-heritage.org.uk*

Keywords: mixed media, mitigation

Even with comprehensive testing of showcase and display materials, certain object materials can have negative effects on other objects in some enclosures. This appears only intermittently in the literature and collections are put at risk from their custodians being unaware of the issue in all instances. A long list of reactions have been observed, including lead with wood, silver with leather/velvet and dark dyes; iron with plastics; glass with paint/paper; shells with original plywood labels; stone with wood; silver with stone and minerals; lead and copper pigments with their frames; silver or copper with archaeological wood/ceramics or metals and Daguerreotypes with their original packets. Enclosure air exchange rates and deterioration products (where identified) in these situations will also be presented. Mitigation options will be explored with examples. Removal is often impossible if both materials occur in a single object. But within a showcase there is sometimes the possibility to select other non-reactive suitable objects, depending on the interpretation message and collection. Similarly blocking emissions is only infrequently possible, generally within enclosures such as glazed frames and Daguerreotype packets. Dilution through increasing air exchange rate can work in some, but not all situations. Measurements and calculations to predict the likely success will be presented. Incorporation of sorbents passively can work with copper, iron and lead but is unlikely to be successful with silver. The use of pumps can overcome this in some situations with careful design of airflows. Lowering temperature can control the off-gassing from particularly problematic materials such as some plastics for storage situations.

Notes:

The BEMMA-Scheme helpful for low VOC inside display cases?

W. Horn[1], O. Hahn[1] and O. Jann[1]

1. *Bundesanstalt für Materialforschung und -prüfung (BAM), Unter den Eichen 87, 12205 Berlin, Germany*

Correspondence: *wolfgang.horn@bam.de*

Keywords: display case, VOC, testing procedure, construction material

Museums worldwide are equipped with different display cases. Exhibit display cases should protect cultural objects from dust as well as from mechanical and physical damage. To ensure a stable climate inside the display cases, a low air exchange rate is maintained. Typically, air exchange rates are often smaller than 0.1 d^{-1}, which can result in rising concentrations of potential harmful VOC inside of the display cases due to emissions from materials. Especially organic acids, e. g. formic or acetic acid which can emit from e.g. sealing materials or wood-based materials, can produce damage of cultural objects.

In 2012 BAM introduced a procedure which is called: BEMMA-Scheme [1] (Bewertung von Emissionen aus Materialien für Museumsausstattungen) which stands for: "Assessment of Emissions from Materials for Museum Equipment". Regarding the testing procedure only construction materials were evaluated, not the display cases their self. Micro chambers are used for VOC emission tests of display case construction materials, e.g. plastics, sealing materials, coatings, textiles and others. Each sampling procedure is carried out in duplicate. Emissions like formic acid, acetic acid, formaldehyde, piperidine-derivates and oximes are excluded and the sum of emissions of VVOCs, VOCs and SVOCs is limited. For a positive assessment all listed criteria must be fulfilled; otherwise the display construction material fails the BEMMA scheme.

In Germany and other European countries for the construction of new display cases a more or less emission free inside air is often demanded. However, the BEMMA scheme is not a guarantee for an emission free display case, but a necessary requirement for the selection of suitable materials for emission reduced display cases. The basic evaluation for the values used for first assessments was a ZIM-project with nearly 100 tested materials. In-between more than 200 new materials were tested and enlarged the knowledge about material emissions from display case materials. Mainly silicone sealing materials were tested because this group of material have the highest emission potential. This founding is also proved by the high emissions of cyclic siloxanes inside of newly constructed display cases. The absolute area of the sealing compounds is often very small, but due to the high area specific emission rates the concentrations can reach very high levels. So it can be shown that it is important for a low emitting display case to plan a sufficient time to allow VOCs to evaporate to lower levels if materials are not free from or having very low emissions. [2]

References

[1] K. Wiegner, W. Horn, O. Jann, M. Farke, O. Hahn, 10th International Conference – Indoor Air Quality 2012, (2012) 25.

[2] W. Horn, O. Jann, O. Hahn, Experience with emission tests of construction material for display cases – submitted to „Cultural Heritage"

Notes:

eOddy – Application of an innovative multiparametric sensor for cost-effective detection of corrosive emissions from display materials

E. Spiegel[1], A. Solbach[2] and A. Hahn[2]

1. *Care for Art, Maximilianstraße 31, D-80539 München, Germany*
2. *BioChip Systems, Maximilianstraße 47, D-80539 München, Germany*

Correspondence: *e.spiegel@care-for-art.de*

Keywords: Oddy, digital, VOC, sensor, display material

The growing number of special exhibitions in particular leads to the use of inexpensive and poorly tested materials, which can have a damaging effect on artifacts. From the point of view of museum professionals, methods for cost-effective and/or continuous measurement of VOC exposure currently available and applied on the market are only suitable to a limited extent. Among the most common methods are the Oddy test (high manual effort, 28 days measurement time until results are available) and fine analytical laboratory test procedures (complex laboratory technology, cost-intensive, requires sampling). Both methods do not allow continuous monitoring.

The approach of the eOddy test is to build on the combination of established systems for corrosion measurement of metals (visual e.g. Oddy test or electrical AirCorr) [1]. A multi-parametric sensor with a combination of in-house developed resistance-based corrosion sensors is used for this purpose. The test principle of the corrosion sensor technology is based on the corrosion of various metals (e.g. from the typical Oddy Test materials: copper, silver and lead) and the resulting increase in electrical resistance, which can be measured and evaluated precisely.

After initial preliminary tests, application procedures for suitable indicator materials are tested which are also suitable for series production. The aim is to integrate different indicator materials on one chip - with the possibility of measuring corrosion electrically and implementing it as a digital eOddy test.

The Oddy test is already widely used to detect corrosive compounds [2]. Lead, copper and silver are used here as classic indicator materials for monitoring object damage. Several additional experiments have followed to further develop the Oddy test and to simplify its interpretation [3]. Compared to the currently available and applied methods, the eOddy is intended to create a significantly faster and more efficient solution that is more suitable for the requirements of museums. Through digitalization and quantification, the duration of the Oddy test could be shortened to 1-2 weeks and would thus also allow to make timely statements and recommendations on the use of non-destructive materials before special exhibitions. Furthermore, a digital Oddy test enables the archiving and comparison of test results (visual test results in the classical test are not suitable for this).

The systematic recording and archiving of measurement results with the eOddy provides a sound database for future risk assessments and the systematic selection of low-emission building and exhibition materials. In addition, the quantification can support the quality management of museums on an ongoing basis. The presentation summarizes the status quo of the eOddy test. The experiments with previous prototypes and materials will be presented.

References

[1] T. Prosek, M. Kouril, M. Dubus, M. Taube, V. Hubert, B. Scheffel, et al. Real-time monitoring of indoor air corrosivity in cultural heritage institutions with metallic electrical resistance sensors. Studies in Conservation 58 (2013), p. 117–128. http://doi.org/10.1179/2047058412Y.0000000080

[2] A. W. Oddy, An unsuspected danger in display. Museums Journal, 73 (1973). p. 2728

[3] H. Heine, A. Jeberien, Oddy Test Reloaded: Standardized Test Equipment and Evaluation Methods for Accelerated Corrosion Testing. Studies in Conservation, 63 (2018) p. 362-365.

L. R. Green, D. Thickett, Testing materials for use in the storage and display of antiquities: A revised methodology. Studies in Conservation 40 (1995), Nr. 3, p. 145-152.

Notes:

Oddy Testing and SPME GC-MS of Double-sided Pressure Sensitive Acrylic Adhesives and Compounds Used to Manufacture Acrylic Adhesives

Catherine H. Stephens[1], Isabella Buscarino[1], Alayna Bone[1] and Eric M. Breitung[1]

1. *The Metropolitan Museum of Art, Department of Scientific Research, 1000 Fifth Avenue, New York, NY 10021 USA*

Correspondence: *catherine.stephens@metmuseum.org*

Keywords: SPME, GC-MS, acrylic, pressure sensitive, adhesive, acid

A study designed to understand why some double-sided pressure sensitive acrylic adhesives failed the Oddy test while others received a temporary rating was completed. Oddy testing of 18 commercially available double-sided acrylic adhesives was run using The Metropolitan Museum of Art's (The Met's) most recent Oddy test method. [1] This approach uses a screw top Pyrex® jar, a 3-D printed nylon coupon holder, and a Viton™ o-ring to seal the samples, metal coupons, and water in the jar. The same adhesives were also analyzed using solid phase micro-extraction (SPME) gas chromatography-mass spectrometry (GC-MS) to see what chemical compounds were volatilized after incubating adhesives at 60°C for 20 minutes then exposing them to a carboxen wide range (WR)/polydimethylsiloxane (PDMS) SPME Arrow fiber for 20 minutes. Concurrent with that work, a separate set of Oddy tests and SPME GC-MS experiments were completed using four different concentrations of a series of control compounds known to be found in acrylic adhesives, namely acrylic acid, methacrylic acid, abietic acid, ethyl acrylate, N-butyl acrylate, and 2-ethylhexyl acrylate. The goals were to understand if any of the individual compounds caused coupon corrosion, what concentration was required to do so, and where those components eluted in the gas chromatogram.

Oddy testing of the control compounds showed that, at concentrations of 0.01% (v/v), both acrylic acid and methacrylic acid corroded the lead coupons. Concentrations one hundred times stronger were required to observe lead corrosion from ethyl acrylate and N-butyl acrylate and ten thousand times stronger for the 2-ethylhexyl acrylate or abietic acid to corrode the lead. Silver coupons were never corroded regardless of the concentration and copper coupons were only corroded at concentrations of 50% (v/v) for the acrylic acid and 0.5M for the abietic acid.

Oddy testing of the commercially available adhesives showed that ten of them received a temporary rating while eight of them failed the test. GC-MS analysis of the adhesives showed that none of them contained ethyl acrylate or methacrylic acid. Abietic acid was not able to be detected using the GC-MS experimental method. Of the remaining three chemicals, it was concluded that acrylic acid was correlated with adhesives failing the Oddy test; however, a certain amount of the acid was required the adhesive to fail. Further investigation into the GC-MS data showed that all of the commercial products contained acetic acid and that, if present in certain quantities, it too contributed to adhesives failing the Oddy test.

References

[1] C. H. Stephens, I. C. Buscarino, E. M. Breitung, Studies in Conservation 63 (2018) S425-S427.

Notes:

Accelerated Corrosion Testing for Museums and Collections – Innovations and Standards in Pollution Control

A. Jeberien[1] and H. Heine[2]

1. *Hochschule für Technik und Wirtschaft Berlin (HTW), Class of Conservation, Wilhelminenhofstr. 75a, D-12459 Berlin*
2. *Museumsverband Thüringen e.V., Wallstr. 18, D- 99084 Erfurt*

Correspondence: *alexandra.jeberien@htw-berlin.de*

Keywords: VOCs, pollution, preventive conservation, accelerated corrosion, *Oddy* test,

The influence of air pollution on cultural heritage collections has been a well-known problem for many years. Although filter systems and absorbents are used to minimize harmful substances, air quality in museums and archival collections is often unsatisfying [1]. Especially, the application of inadequate material for display cases and mounts, as well as for storage and packing solutions contribute to poor air qualities. As new products enter the market every day, it is crucial to control the risk of air pollution for cultural heritage collections.

For many years an accelerated corrosion test (so called *Oddy* test) has been a meaningful tool for conservators and conservation scientists [2]. Performed on a regular basis, it enables museum's staff to minimize risks and damage due to pollutants. However, the original set-up of the *Oddy* test shows striking limitations, as there are numerous variations in equipment and procedures, and a rather subjective evaluation method, all influencing the significance of test results. Subsequently, various approaches to further develop the *Oddy* test have been made the past years.

Taking into account the importance of accelerated corrosion testing for preventive conservation the *Material Checker* (MAT-CH) project at HTW Berlin has explored the most established '3 in 1' test version recommended by Robinet and Thickett [3]. MATCH research focussed on the innovation of the test equipment, like re-usable reaction vessels completely made from inert materials (fig.1), as well as on ready-to-use metal indicators (fig. 2). Both innovations aim to simplify the test set-up and streamline the procedure, thus not only reduce preparation time, but also safe valuable resources. Furthermore, MAT-CH explored a revised evaluation system, which combines a customized photography set-up connected to software-based neural networks (AAN) in order to facilitate objective ratings.

Fig. 1: MAT-CH reaction vessel.

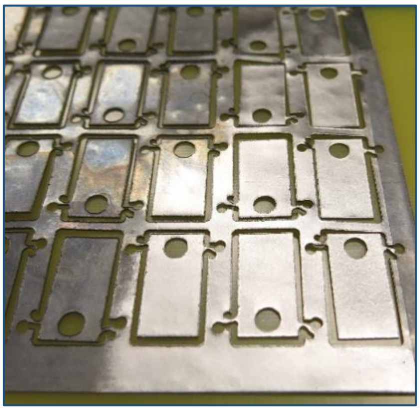


Fig. 2: Grid cut and partly cleaned lead indicators.

Finally, round-robin tests executed in three natural history collections in Germany evaluated MAT-CH in comparison to the established *Oddy* test. Results have shown a significant reduction of preparation time, leading to savings of time, money and resources, though distinct enhancements of test results. To complete the project, HTW Berlin just recently teamed up with Technical University of Berlin. MAT-CH 2.0 will finalize the innovation, afterwards production and distribution of MAT-CH can hopefully start.

References

[1] Grzywacz C.M., Monitoring for Gaseous Pollutants in Museum Environments, in: Tools for Conservation, The Getty Conservation Institute Los Angeles, 2006, Chapter 1, 2 and 6

[2] Oddy A.W., An Unsuspected Danger in Display, Museums Journal 73 (1973), Nr. 1, pp. 27-28.

[3] Robinet L.R. and Thickett D., A New Methodology for Accelerated Corrosion Testing, in: Studies in Conservation 48 (2003), pp. 263-268.

Notes:

What's in the news? The micro-environment inside stacked paper.

M. Ryhl-Svendsen[1]

1. *The Royal Danish Academy of Fine Arts School of Architecture, Design and Conservation, Esplanaden 34, 1263 Copenhagen, Denmark*

Correspondence: *mrsv@kadk.dk*

Keywords: microclimate, paper, organic acids, diffusion, ventilation

It is a common assumption that the microclimate inside a box, a book or between the sheets of paper in a stack is very stable due to a large loading of hygroscopic material, and with a high blockage rate for any ingress of pollutants. Likewise internally generated pollutants are thought to build up in high concentrations, if a source is present, e.g. by release from the paper itself during degradation processes. I have previously demonstrated, however, that archival corrugated card board boxes are quite transparent to mass transfer between the inside of the box and the room air [1,2].

When discussing air quality in storage rooms a common point of discussion is if the ventilation rate can be allowed to be low (for saving energy) or should be higher in order to ventilate away internally generated pollutants. However, for collections such as archival records or books, made from acid paper bound or in stacks, it is also unclear if ventilation has any effect on the microenvironment inside the paper stack at all.

In an ongoing laboratory test series the level of organic acids inside a stack of newspaper is measured at high or low ventilation rates. This is performed by using passive diffusion samplers (IVL Sweden) as emission rate monitors rather than concentration in air samplers. This is combined with a visualization, made by the use of pH indicator paper ("AD Strips"), on the acid migration through a stack of paper either generated within the paper itself, or if suddenly exposed to a high concentration in the ambient air. From this the steady state balance of organic acid production, transfer rate through the paper stack, and removal by ventilation is established. The experimental campaign is ongoing and results are still few at the time of abstract submission, however, a preliminary overall conclusion is that a stack of paper is much better ventilated, all the way through the block, than one would instinctively suppose.

References

[1] Ryhl-Svendsen, Grinde & Christoffersen (2008): "The microclimate inside archival boxes in rooms with fluctuating relative humidity and temperature". Poster for ICOM-CC 15th Triennial Conference, New Delhi.

[2] Ryhl-Svendsen (2010): "The micro-environment inside archival boxes. Part 2: Air pollution". COST D42 Final Conference, Dublin.

Notes:

The impact of air motion on indoor microenvironments: passive ventilation strategies for historic bookshelves

M. Ferreira[1], J. Grau-Bové[1], N. Blades[2] and H. Altamirano[3]

1. *UCL Institute for Sustainable Heritage, 14 Upper Woburn Place, London, WC1H 0NN*
2. *National Trust for England, Wales and Northern Ireland (UK)*
3. *UCL Institute for Environmental Design and Engineering (UK)*

Correspondence: *Morena.ferreira.16@ucl.ac.uk*

Keywords: mould, air movement, historic buildings, preventive conservation

Mould development is responsible for the biological deterioration of historic materials such as books in historic buildings. Environments with lower temperature and higher relative humidity levels contribute to mould development, such as microclimates formed behind books in bookshelves in historic buildings. It is believed that increasing air motion through the use of ventilation holes in shelves can eliminate these microclimates.

Two challenges with air motion in indoor historic spaces were found: it is difficult to control and it is difficult to measure. Following the use of ventilation holes as a method of control proposed by the National Trust (United Kingdom), a measurement method for air movement was developed. Challenges found include a) air velocities measured in situ being very close to the limit of the instrument used (0.01 m/s), b) the necessity to removing books from shelves for access due to the size of the instrument, which also poses the risk of altering the flow depending of alignment with the holes, c) long term measurements resulting in very high amounts of data making data processing complex and d) understanding causality of velocities not being trivial. A WindSonic™ with ultrasonic wind sensor was used.

To characterize air movement behind bookshelves and assess whether the use of ventilation holes works and how, experiments were carried out both in a full-scale shelf in laboratory conditions and on-site in bookshelves in libraries in National Trust properties. Three historic properties with different mould incidences were selected. Air movement, relative humidity and temperature within a bookshelf of each property were monitored over a period of six days during summer. It was found that the air movement measured behind books is related to that detected in the rooms during the same period (e.g. peaks of higher velocities during the properties opening times). The lower velocities measured in the case study with higher occurrence of mould could also indicate a correlation between the presence of air movement and mould growth in microclimates.

To further understand air movement, two types of air passages were explored behind the books on a purpose-built bookshelf: round holes (2.5 cm diameter), currently being tested by the National Trust, and two continuous gaps (3 and 1 cm). Three scenarios were tested using an electric fan: still air, a lower velocity (avg. 0.13 m/s) and a higher velocity (avg. 0.40 m/s). It was observed that there is no significant difference in velocities measured with both 1 and 3 cm gaps when testing a lower air velocity. However, this difference increases with a higher velocity. Velocities achieved using holes are comparable to those achieved with a 1 cm continuous gap.

In summary, this study has demonstrated that holes in bookshelves can improve air circulation when there are external sources of air movement. Parameters such as hole size and shelf dimension seem to be of secondary importance: what matters is that microenvironments are connected with external environments. The significance of the different velocities measured was explored in order to better understand its ability to impact on microclimates.

Notes:

Modeling the degradation of acidic, neutral and alkaline papers

J. Tétreault[1], P. Bégin[1], D. Vedoy[1], S. Paris-Lacombe[2], Denis Réau[2] and Anne-Laurence Dupont[2]

1. *Canadian Conservation Institute, Canadian Heritage, 1030 Innes road, Ottawa, Ontario, K1B4S7, Canada*
2. *Centre de Recherche sur la Conservation des Collections (CRC, CNRS USR 3224), Muséum National d'Histoire Naturelle, 36 rue Geoffroy St Hilaire, 75005 Paris, France.*

Correspondence: *jean.tetreault@canada.ca*

Keywords: Cellulose; Degradation; Molar Mass Distribution; Deconvolution; Alkaline

To predict the useful lifetime of paper, the classical approach is to use accelerated ageing as a means to simulate, over short periods of time, all the changes that occur in the cellulose over the long periods of natural ageing. Implicitly, the hypothesis is that the artificial conditions used induce the same modifications as natural ageing and that only the rate of each reaction is magnified. However, this hypothesis is not always straightforward as the the ageing processes are complex. The present work addresses this complexity. For instance, taking into consideration the change in the moisture content and in the acidity of cotton linters paper with no additives (Whatman #1) during the ageing allowed to refine the predictive kinetic model [1]. For the more complex lignocellulosic papers, deconvolution methods of the multimodal molar mass distributions measured by SEC/MALS/DRI were developped in order to untangle the contribution of the different biopolymers present (cellulose, hemicelluloses, and residual lignin), and obtain accurate data of the degradation of cellulose [2]. These recent developments allowed us to expand the predictive model to acidic and alkaline cotton and woodpulp papers with common papermaking additives ($CaCO_3$, AKD or alum-rosin). An Arrhenius study was undertaken in hygrothermal conditions at temperatures ranging from 60 ºC to 100 ºC, to predict the useful lifetime of the different papers. To this purpose, the moisture content, pH, $CaCO_3$, and zero-span breaking length of paper and the average molar masses of cellulose were measured at all ageing temperatures and durations.

As expected, the presence of $CaCO_3$ fillers in the paper enhanced the predicted lifetime by buffering the acids produced during ageing. Conversely, the neutral and acidic papers showed lower resistance towards ageing due to their increasing acidity. The results obtained allowed to quantify the stabilty and unstability of the different papers, and provided a better characterisation of their longevity.

References

[1] J. Tétreault, A.-L. Dupont, P. Bégin, S. Paris. "Modelling considerations for the degradation of cellulosic." Cellulose, 26 (2019) 2013 – 2033.

[2] A.-L. Dupont, D. Réau, P. Bégin, S. Paris-Lacombe, J. Tétreault, G. Mortha. "Accurate molar masses of cellulose for the determination of degradation rates in complex paper samples." Carbohydrate Polymers, 202 (2018) 172-185.

Notes:

Material research on the lead alloyed printing types and environmental mitigation actions in the Plantin-Moretus museum, Antwerp

Patrick Storme[1] and Werner van Hoof[2]

1. *University of Antwerp, Faculty of Design Sciences, Conservation Department, Blindestraat 9 B-2000 Antwerp*
2. *Museum Plantin-Moretus, Vrijdagmarkt 22 B-2000 Antwerp*

Correspondence: *patrick.storme@uantwerpen.be; werner.vanhoof@antwerpen.be*

Keywords: slow conservation, preventive conservation, corrosion, lead, XRF

The museum Plantin-Moretus in Antwerp (Belgium) was the home and workplace of the 16th century printer/publisher Christophe Plantin and later the Moretus family. It is a historic house with an art collection, a printing museum, archive, library and print room in one. It is recognized as world heritage by UNESCO.

Conservation of the vast collection in this historical housing has always been a challenge. In view of good management of the collection, the museum cooperates with several research institutions to measure and monitor the museum conditions. Since 10 years, the museum has undergone several changes in terms of spatial organization and conservation-related building changes. In 2008-2012 there were long-term studies to assess the pollutants and conditions of conservation. In 2014-2017 there was a study to develop long term solutions for temperature and humidity. With the results of these two studies in combination with the principals of 'Slow Conservation' improving museum conditions are considered a top priority. The concept of slow conservation involves preventive maintenance, taking local conditions as a starting point, participation of a wide range of people and assessing of the impact on the environment. As a case we present in this contribution the research project on the collection of printing types that were kept in wooden trays for hundreds of years.

The lead types that were used for printing, are composed mainly of lead but with additions of tin and antimony in various amounts. It was noted in the past that some of these types were corroded whilst others barely showed any corrosion, nonetheless they were kept in the same environmental conditions. Previous research has shown that the concentrations of tin and antimony play an important role in the development of corrosion, in combination with the volatile organic gas emissions by the wooden typecases, the oak furniture and the building materials of the historic houses as a whole [1,2].

A recent survey of the types collection was executed using X-ray Fluorescence as the analytical technique for determining the types' compositions, together with a visual corrosion inspection. Five groups of corrosion were established: group **0** with extreme lead corrosion (5 trays); group **1:** severe corrosion (27 trays); group **2:** moderate **corrosion (45 trays); group 3: minor corrosion or discoloration (56 trays) and finally group 4 with no visible corrosion (203 trays). The results show the relation between the lead alloy composition, i.e. the tin/antimony concentrations and corrosion development.**

References

[1] Storme Patrick, Jacobs Marjan, Lieten Emilie, Research on corrosion of lead printing letters from the Museum Plantin-Moretus, Antwerp, Procedia Chemistry, 8(2013), p. 307-316

[2] Ghiara Giorgia, Campodonico Serena, Piccardo Paolo, Martini Carla, Storme Patrick, Carnasciali Maria Maddalena, Micro Raman investigation on corrosion of Pb-based alloy replicas of letters from the museum Plantin-Moretus, Antwerp, Journal of Raman Spectroscopy, 11-12 (2014), 1093-1102

Notes:

Crizzling in Spanish Royal glasses, how to preserve them in historical buildings?

T. Palomar[1], P. Pastor[2] and N. García-Patrón[3]

1. *Instituto de Cerámica y Vidrio (ICV-CSIC), c/ Kelsen 5, Campus de Cantoblanco, 28049 Madrid, Spain*
2. *Real Fábrica de Cristales de La Granja, Paseo del Pocillo 1, 40100 La Granja de S. Ildefonso, Segovia, Spain*
3. *Patrimonio Nacional, Palacio Real 28071 Madrid, Spain*

Correspondence: *t.palomar@csic.es*

Keywords: glass, crizzling, Spanish Royal Glass Factory, environmental study, volatile organic compounds.

Crizzling is an alteration pathology related to non-equilibrated glasses (high content of flux oxides and low content of stabilizer ones), which can produce a fast surface alteration. This pathology has been observed in historical glass pieces predominantly from the 17th to 19th centuries from Italy, UK, and Central Europe. In Spain, there are also pieces affected by this severe pathology in two of the most important Spanish glass collections: the Royal Palace of Madrid and the Technological Museum of Glass. Most of the pieces with crizzling in both collections were high-quality pieces produced by the "Real Fábrica de Cristales de San Ildefonso" (Spanish Royal Glass Factory) in the first decades of the 19th century, during the reign of King Ferdinand VII. These glasses show transparency losses, surface cracking and peeling. Some of the pieces are in exhibition, but most of them are preserved in storage rooms.

The aim of this work is to make a comprehensive study of both collections for understanding the low quality of the glass in these pieces and how the environment is affecting them. To assess the surface pathologies, a set of portable analytical techniques, including a digital microscope and portable X-ray fluorescence spectrometer, were applied. The showcases, cabinets, and rooms with the damaged glasses are being monitored to assess the real condition of their surrounding environment and to identify possible sources of contaminants. External positions are also monitored to compare the evolution of the environmental parameters. Acidity sensors, passive samplers based on diffusion technology and thermo-hygrometers are being analyzed periodically to estimate the annual variation of the environment and to detect possible emission sources of organic acids.

In the Royal Palace of Madrid, daily temperature cycles were observed in the whole the building, even inside the wardrobes where the glasses were preserved in the storage room. However, in this position, variations of just ± 0.5 ºC were detected. The temperature inside the Royal Palace, in the showrooms and storages, was nearly constant between 20 and 24 ºC. The Technological Museum of Glass, located in the Spanish Royal Glass Factory, showed also the daily temperature cycles outside and in the showroom, but it was minima in the storage room. Nevertheless, the overall temperature was very influenced by the external temperature.

Regarding the atmosphere, the sensors installed in the Royal Palace of Madrid showed a slightly acid atmosphere because it is placed in the urban atmosphere of Madrid, instead of the Technological Museum of Glass, which is located in the rural town of La Granja de San Ildefonso. The passive samplers detected a high concentration of formic acid in some locations, mainly related to the presence of wood wardrobes.

Notes:

Application of thermoanalytical techniques to case studies in preventive conservation and novel conservation treatments

M. Odlyha[1], D. Thickett[2], C.Pearce[1], A. Fennelly[1], C. Theodorakopoulos[3], K. Zarnaveli[1], G. Andrade[4], A.Bridarolli[5], A. Bartoletti[6] and L. Bozec[7]

1. Dept. of Biological Sciences, Birkbeck, University of London, Malet St London WC1E 7HX
2. English Heritage, Ranger's House, Chesterfield Walk, London SE10 8QX
3. City Campus 001 Burt Hall, Northumberland Road Newcastle upon Tyne NE1 8STUniversity of Newcastle
4. SIT Spain, Calle Rioja, 528823 Coslada, Madrid
5. Getty Conservation Centre, Los Angeles, California
6. New University of Lisbon, Portugal (formerly UCL and Tate, London, UK)
7. University of Toronto, 124 Edward Street, Room 459 | Toronto, ON M5G 1G6 (formerly UCL)

Correspondence: m.odlyha@bbk.ac.uk

keywords: damage assessment, leather bookbindings, microclimate monitoring, novel conservation treatment

Recent and ongoing case studies have been performed in collaboration with both English Heritage and the art transport company (SIT, Spain) and three examples will be presented. These include damage assessment of historical leather bookbindings, monitoring microclimates within museums, historic houses, and storage locations, and evaluation of the state of storage containers used for archaeological objects.

The first example describes assessment of the state of preservation of collagen in historical leather bookbindings. The introduction of multi-scale analytical techniques in the IDAP project (Improved Damage Assessment of Parchment) has widened the understanding of degradation pathways from the macro to the nanoscale level of collagen in parchment. The same approach was then translated and used in the NANOFORART project to study the effects of conservation treatment on both parchment and leather. In this study fibre samples of leather (red and black) were extracted from leather bindings (Charles Darwin's notebooks) and examined using Atomic Force Microscopy (AFM). The resulting images revealed details of structure at the nanoscale. The D-banding of the collagen was found to be more intact for the red-coloured fibres than for the black coloured fibres which showed regions of gelatinization indicating damage to the collagen. The extent of damage could be correlated with existing data from both accelerated aged and historical samples. These were measured on samples both at the nano and also at the macro-scale by thermoanalytical techniques. Current work has extended this to archaeological bone.

The second case study involves monitoring of microclimates in museums, historical houses and storage locations with dosimeters for interrogating corrosiveness of these environments. Dosimeters include coated piezoelectric quartz crystals (PQC), varnish coated metal strips, and metal coupons. Exposure of varnish coated dosimeters at selected English Heritage sites within the MEMORI project and their evaluation by thermoanalytical techniques will be shown. In addition examples of the use of lead coated PQC dosimeters within frames of paintings, and locations within showcases will be shown. The effect on canvases of adverse conditions and recently proposed novel nano-based treatment for their consolidation will be described. Some developmental work on dosimeters using nanoparticle based coatings on PQC crystals to monitor microclimate within daguerrotypes of Charles Darwin's family will be presented.

The third case study involves the characterisation of plastic storage boxes and bags used to store objects. These were characterized by Fourier transform infra-red (FTIR) spectroscopy differential scanning calorimetry (DSC), and thermogravimetry (TGA). Measurement was made of their degree of crystallinity together with their thermal stability. A reduction of crystalllinity will increase the permeability of polymers. This is not what is required for the storage boxes so estimation of crystallinity fraction is an important parameter for characterising the boxes. In the case of the storage bags DSC showed a difference between older and newer bags. Though still mainly based on polyethylene (LDPE) they also contained other components, possibly due to increase in recycling. Accelerated ageing tests have revealed that object type stored in bag affects its thermal stability. This could have implications on life time for storage of objects.

Notes:

Investigation of Fogging on Glass Display Cases at the Royal Ontario Museum

Jennifer Poulin[1], Helen Coxon[2], Jason R. Anema[1], Marie-Claude Corbeil[1] and Kate Helwig[1]

1. *Canadian Conservation Institute, 1030 Innes Road, Ottawa, Ontario, Canada K1B 4S7*
2. *Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, Canada M5S 2C6*

Correspondence: *helenc@rom.on.ca*

Keywords: museum display cases; fogging residues; glass cleaning protocol; analytical investigation

Shortly after a major renovation at the Royal Ontario Museum, it was noticed that the glass panels in many of the new display cases exhibited fogging or hazing on the surface, sometimes in very specific patterns. Cleaning removed the fogging temporarily, but it began to reappear within 12-18 months, even after multiple cleanings. An investigation of fogged glass panels in display cases was undertaken to understand the source of the fogging and to develop an appropriate mitigation or cleaning method. The investigation included the analysis of residues from glass panels in several galleries, and surface imaging and compositional analysis of glass panels.

The fogging residues on the glass panels consist mainly of sodium salts of organic acids and inorganic anions. Sources of the sodium in the residues include air particulate matter and the glass itself. The organic acids and inorganic anions that form salts with the sodium cations probably originate from volatile organic compounds (VOCs) and particulate matter in the air. Examination of the fogging patterns on the glass panels revealed that the manufacturing process and subsequent cleaning attempts leave greasy residues on the glass which encourage crystal growth. Because of the variation in surface cleanliness, panels with more cleaning and manufacturing residues appear to be heavily fogged while those with less may appear to be unfogged in the museum display cases. A cleaning protocol was tested on two of the glass panels, and was found to remove all traces of grease and fogging residue. Current investigations are focussed on methods to clean display cases with minimal need to remove case furniture and de-install artifacts.

Notes:

Crystalline deposits in new display cases of the Rijksmuseum

J.M. van Iperen[1], H. van Keulen[2], K. Keune[1], K. Abdulah[1] and R. Van Langh [1]

1. *Rijksmuseum, Department Conservation & Science, Museumstraat 1, Postbox 74888,1070DN, Amsterdam, The Netherlands*
2. *Cultural Heritage Agency, The Netherlands*

Correspondence: *J.van.Iperen@rijksmuseum.nl*

Keywords: crystalline deposits, constructive adhesive, Terostat-9220, Tinuvin-770

Five chemically different crystalline deposits were found in the new display cases of the Rijksmuseum four months after their installation in April 2013. The white deposits were visible to the naked eye and appeared on glass windows, silicone door gaskets, on seals of black constructive adhesive, and on works of art. Main works of art affected by these deposits were bronze sculptures, wooden and waxed objects, tempera and oil paintings. The deposits were chemically characterised using (pyrolysis) gas chromatography- mass spectrometry, μ-Raman spectroscopy, ion chromatography, and scanning electron microscopy combined with energy dispersive X-ray spectroscopy. The crystalline deposits were identified as organic salts of the base 2,2,6,6-tetramethyl-4-piperidinol (TMP-ol), a secondary amine, and five different carboxylic acids. The identification was supported by the syntheses of the deposits in the laboratory. It was found that the TMP-ol, which is part of the light stabiliser Tinuvin-770, was emitted from the constructive adhesive Terostat-9220. Terostat-9220 was used in large quantities in the display cases to adhere glass windows to metal parts. The carboxylic acids derived from both construction materials used to build the cases, and from conservation materials present on the exhibited works of art. The carboxylic acids involved were 2,4-dichlorobenzoic acid, formic acid, methacrylic acid, palmitic acid and an unknown carboxylic or amino acid. These carboxylic acids were respectively emitted from peroxide-cured silicone gaskets, panels of Medium Density Fibre board (MDF-WJ), UV-glue, beeswax, and an unknown conservation product or disinfectant (Figure 1).

Hundred eighty display cases were polluted. In order to prevent the adhesive to continue releasing TMP-ol into the display cases, the inside adhesive seals were covered with the two-component epoxy Araldite-4859. Airtight seals were gained by heating the epoxy for five hours at 60 ºC. Deposits did not return in hundred seventy-eight display cases. In two display cases deposits returned due to broken Araldite seals. Four hundred seventy-three objects were cleaned and MDF-WJ back panels, as the source of formic acid, were removed and replaced by DiBond panels, made of aluminum and polyethylene.

Despite emission and aging tests of the construction materials prior to installation of the display cases in 2013, tests on the content of TMP-ol was not carried out. We believe that the component TMP-ol accidently occurred in Terostat-9220, probably as a failure of the adhesive production.

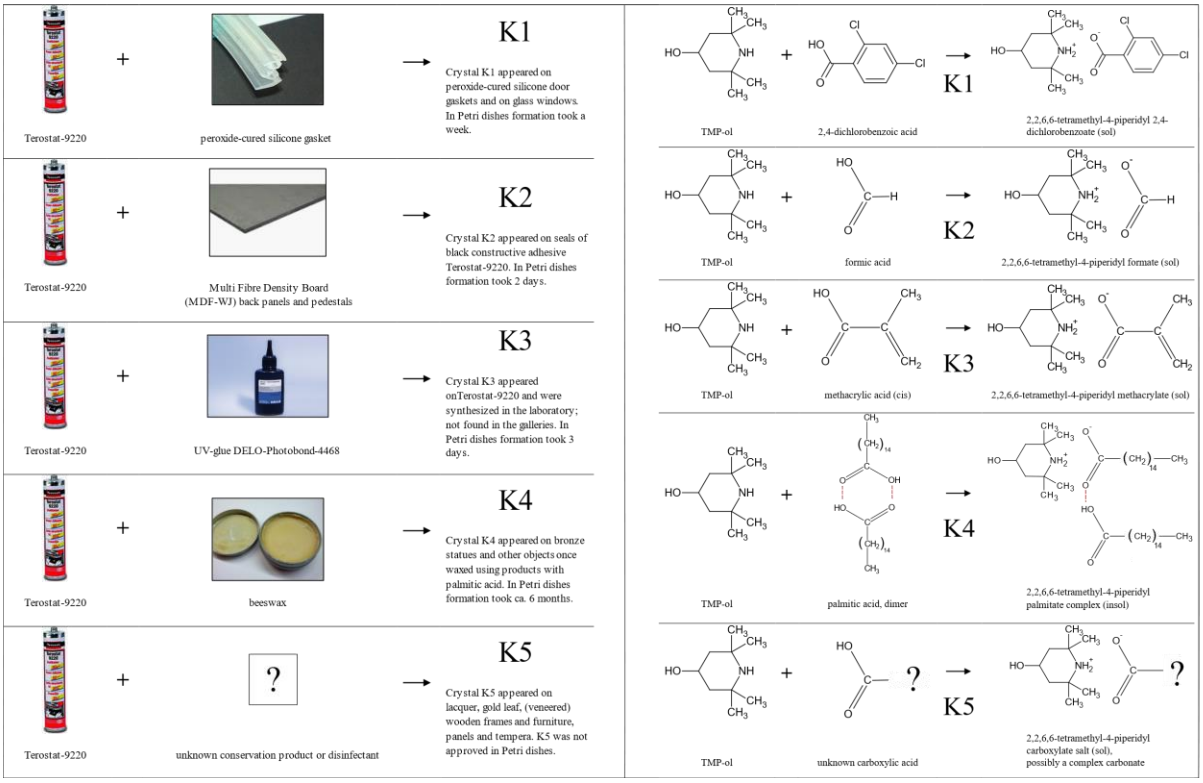


Fig. 1: An overview of the construction and conservation materials involved in the formation of the five different deposits (left), and the involved compounds, their (proposed) structural formula's and reaction equations (right). K = kristal = crystal, TMP-ol = 2,2,6,6-tetramethyl-4-piperidinol, (in)sol = (in)soluble in water, dotted line = hydrogen bond.

Notes:

Functionalized silica adsorbents for pollution reduction in cultural heritage environments

E. Canosa[1], K. Grenda[1], M. Persson[2], K. Holmberg[1], R. Bordes[1] and S. Norrehed[3]

1 *Chalmers University of Technology, Chalmersplatsen 4, SE-412 96 Gothenburg, Sweden*
2 *Nouryon Pulp and Performance Chemicals AB, Färjevägen 1, SE-445 34 Bohus, Sweden*
3 *The Swedish National Heritage Board, Artillerigatan 33A, SE-621 38 Visby, Sweden*

Correspondence: *elyse@chalmers.se*

Keywords: adsorbents, pollution, storage, preventive, preservation

Airborne pollutants in museum storage environments pose a major threat to the longevity of collection objects. They induce corrosion, fading, cracking, and other forms of deterioration. Adsorbents can be used to reduce these pollutants, but there is a lack of affordable products tailored specifically for museum environments. The purpose of this project is to develop an adsorbent that captures pollutants known to deteriorate cultural heritage objects. The adsorbent is composed of a silica gel support loaded with polyethylenimine (PEI), both of which are low cost and readily available materials, making the production process easy to upscale. The silica gel provides a high surface area support for efficient adsorption, while PEI is known for its ability to capture acidic gases.

During material development, various silica and PEI combinations were investigated using five different types of silica and four different types of PEI. All samples were characterized to understand the adsorption mechanism and capacity, and to determine the most effective silica-PEI combination for pollution mitigation. Characterization involved exposing the adsorbent to seven different gases known to deteriorate cultural heritage objects: acetic acid, formic acid, acetaldehyde, formaldehyde, sulfur dioxide, nitrogen dioxide, and hydrogen sulfide. During gas exposure, the adsorption mechanism for each individual gas was investigated using in situ diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) and the adsorption capacity was determined using mass spectrometry of the effluent gas. Additionally, accelerated aging tests were performed at elevated temperature and humidity to observe potential degradation. Emissions from the aged adsorbents were investigated using viscometry measurements of reference cellulose and the Oddy test.

Following characterization, select adsorbent samples were used to perform field tests in collaboration with Swedish cultural heritage institutions. Storage containers with suspected elevated concentrations of pollutants were chosen as case study locations. During the field tests, the air quality within the containers was monitored before and after adsorbent installation using sensors and diffusive air samplers. Activated charcoal was also used in the field tests as a comparative material. Such information provides data on how the adsorbent performs in realistic storage environments. In the future, the optimized silica-PEI product will be integrated into affordable, simple to use end-products for preservation professionals. Such products can include coatings or foams that are easily added to existing storage containers and passively protect objects against pollution-based deterioration.

Notes:

Climate Improvement for Paintings and Visitors in Affandi Museum, Indonesia

W. Stumpf[1]

1 *Donau Universität Krems, Department für Bauen und Umwelt, Dr.-Karl-Dorrek-Strasse 30, 3500 Krems, Austria*

Correspondence: *wolfgang.stumpf@donau-uni.ac.at*

Keywords: natural, ventilation, monitoring, simulation, comfort

The private Museum Affandi is located in Yogyakarta on Java island in Indonesia. The artist Affandi (1907-1990) himself designed the Gallery 1 (Fig. 1) which is part of a museum complex where he worked, lived and is buried. The building was opened in the early 1970ies to exhibit his oil paintings and paper works. No active air conditioning system was installed which is typical for art galleries in this area until today. The local climate is very warm and humid. Over the year temperatures range from 20 to 39°C, in average 29°C and 72 % relative humidity. The artwork, visitors and buildings are suffering under such circumstances. Due to dust and noise coming from the adjacent busy road, ventilation openings in the walls were partly closed, natural ventilation is not working in an efficient way.

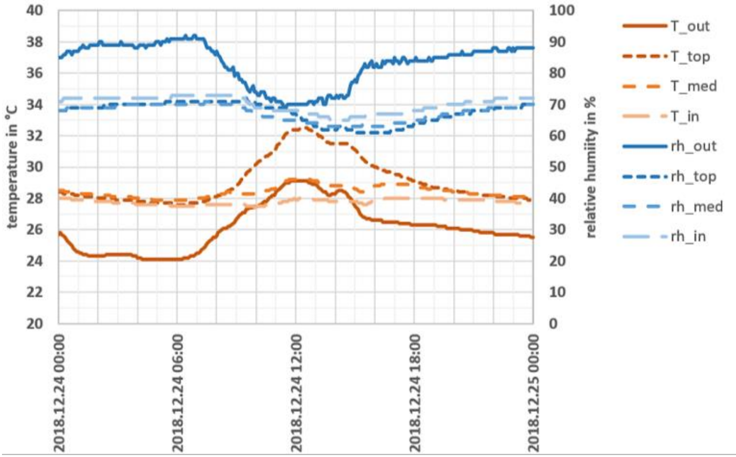
In the year 2012 Vienna University of Technology did a building survey of the whole Museum area. They drew inventory plans, documented the building history and the state of the construction, started with building physical analysis. The result was a renovation concept [1]. Beside the reduction of direct solar radiation entering the building through the roof windows two air chillers were installed. Further recommended measures were not carried out until today.

Fig. 1: Gallery 1 of Affandi Museum in Yogyakarta, Indonesia.
Does hybrid ventilation provide an optimum climate for art and visitors in Gallery 1?

During opening hours two air chillers blow cold air into the room. This reduces the air temperature down to 26 °C. Strong air movements transport dust onto the paintings, adaption of the ventilator position and some art restorations were needed. At night, room surfaces and air cool down by about 2-3°C, but the humidity fluctuates by about 5-7 % over one day.

In August 2018 the author checked the danger of condensate and mold growth on the inner building surfaces of Gallery 1. The dew point temperature was not exceeded at any time or point. Since December 2018 a climate monitoring system has delivered data about temperature, relative humidity,

CO_2, noise and outdoors temperature, humidity, precipitation and wind (Fig. 2). With this information the hybrid ventilation controlled by the museum staff and by wind and temperature driven air flows through leakages in the building envelope can be analyzed. Therefore, the thermal comfort in Gallery 1 and hygrothermal behavior in the building construction are reconstructed and optimized by dynamic computer simulations. The results are communicated to the museum which takes these recommendations for airing into account. WLAN sensors monitor the consequences on the indoor climate, further computer simulations support optimization efforts [2].



	avg	min	max
T_out	26,1	24,1	29,1
T_top	29,1	27,6	32,5
T_med	28,4	27,9	29,2
T_in	27,8	27,4	28,0
rh_out	83	69	92
rh_top	67	61	72
rh_med	67	63	71
rh_in	70	65	73

Fig. 2: Temperature and relative humidity in and around Gallery 1.

As a result, in Gallery 1 the thermal comfort for paintings and visitors have been improved but are not yet fully satisfactory. The climate in and around the museum over one year is documented in detail. With the help of WLAN climate sensors, the museum staff observes and learns from the interaction between weather, number of visitors, air flow through the building. This still ongoing project helps to find answers to the more frequent and prolonged heat waves in Europe.

References

[1] U. Herbig, G. Styhler-Aydin, D. Grandits, L. Stampfer, U. Pont: The Architecture of the Affandi Museum: Approaches to a Piece of Art. 3rd Biennale of ICIAP – International Conference on Indonesian Architecture and Planning, proceeding page 18-27, Department of Architecture and Planning, Faculty of Engineering, Gadjah Mada University, Yogyakarta, Indonesia, 2016.

[2] W. Stumpf: Reconstruction of the use of space of historical buildings from the simulation-based thermal analysis of the building façade. 13th Conference on Advanced Building Skins, proceedings page 913-922, Bern, Switzerland, 2018

Notes:

Are our management actions good enough to preserve collections?

N. G. Saraiva[1], G. Pereira[2], A.R. Gaspar[1] and J.J. Costa[1]

1 *ADAI, LAETA, Department of Mechanical Engineering, Universidade de Coimbra, Coimbra, Portugal*
2 *MCUC, Museu da Ciência da Universidade de Coimbra / Centro de Física da Universidade de Coimbra, Portugal*

Correspondence: *nuno.saraiva@dem.uc.pt*

Keywords: preventive conservation, monitoring, hygrothermal conditons, heritage buildings

Historic buildings which are open to tourists require an extra care when it comes to the management process. It is intended to provide the best cultural experience possible while, at the same time, ensuring an appropriate conservation standard. The problem arises when the management staff is not qualified enough or implements strategies that do not meet the patrimony needs. Opting to install climate control equipment, changing the touristic circuit, making disinfection treatments, among others, are examples that make part of the management practice. However, some of them only consider the economic factor jeopardizing its actual impact and the quality of the service. As a result, it is interesting to address the impact of such actions on the indoor environment because they can contribute to the collections' degradation.

This study was centred on the evaluation of recent management actions that may have had impact on the hygrothermal environment and consequently on the conservation of collections in two eighteenth-century buildings located in Coimbra, Portugal: a historic library [1] and a university museum [2]. The measures analysed included: (i) the disinfestation treatment of a collection in a showcase, (ii) the installation of dehumidifiers in some spaces, and (iii) the installation of an anoxia chamber in an archive. Then, the work was carried out recurring to the analysis of measurements of the indoor environment conditions collected from a monitoring campaign, hygrothermal. Besides the hygrothermal assessment, it was started the monitoring of CO_2 in one space to study the influence of these actions on its concentration. The timeframe of the actions was registered in order to compare with previous situations throughout the analysis. The approach started with a preliminary interpretation of the hygrothermal behaviour before, during and after the actions' implementation. Afterwards, the methodology was complemented with the assessment of the measured data using the concept of Performance Index (PI) [3], with reference to the thresholds recommended by the most used conservation standards.

From the results, it was possible to recognise perceptible changes in the natural evolution of the hygrothermal conditions for almost every situation. Figure 1 represents one example of the consequences of not implementing correctly a management decision − mentioned above as (ii). Nevertheless, this first approach did not allow the quantification of the impact on the collections' preventive conservation. Therefore, these results reveal the need to comprehend other analysis tools taken from conservation standards, which will be addressed in a close future.

In conclusion, every measure implemented can be associated with some events that may harm collections. Therefore, they should be carefully studied to derive the best possible outcomes. The present work intended to evaluate how maintenance and preventive measures can be related to induced-stress in the hygrothermal environment and consequently affect conservation if poorly executed. For this reason, awareness and experience are crucial and the decision-making process should be based on preventive strategies that must include a previous monitoring campaign.

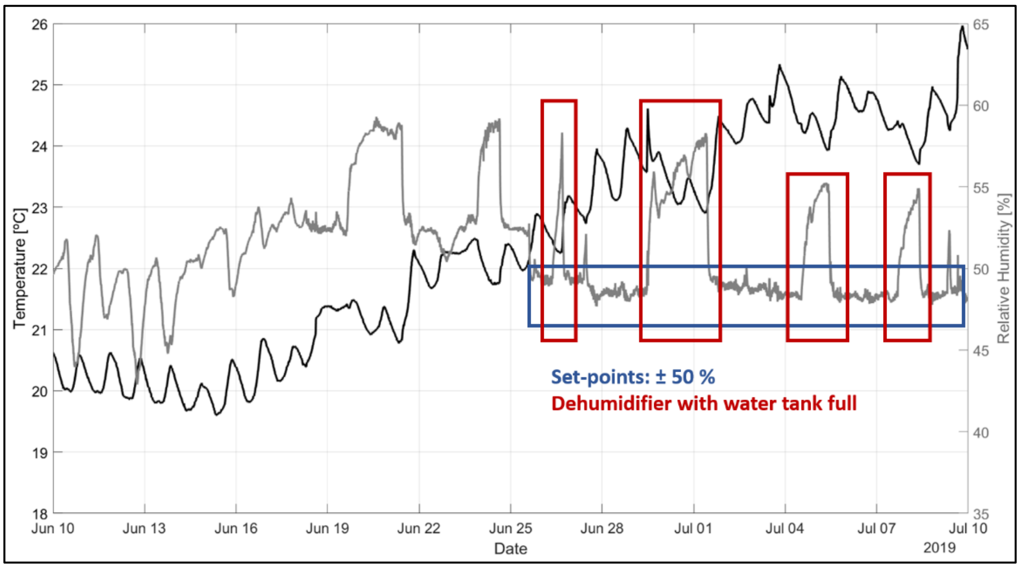


Fig. 1: Having the dehumidifier's water tank overloaded led to an unnecessary fluctuation of the relative humidity within the space.

References

[1] Pereira, L. D., Gaspar, A. R., & Costa, J. J. (2017). Assessment of the indoor environmental conditions of a baroque library in Portugal. Energy Procedia, 133, 257–267.

[2] Pereira, L. D., Gaspar, A. R., Costa, J. J., & Pereira, G. (2019). The importance of long-term hygrothermal assessment of museum spaces: method and application in a permanent exhibition in a historical building. Conservar Património, 30, 91-105.

[3] M. Andretta, F. Coppola, & L. Seccia (2016). Investigation on the interaction between the outdoor environment and the indoor microclimate of a historical library. Journal of Cultural Heritage, 17, 75–86.

Notes:

How to Citizen scientists and indoor air quality

J. Grau-Bove[1]

1 *Institute for Sustainable Heritage, University College London, London, UK*

Correspondence: lome.creu@gmail.com

Keywords: pollutants, deposition, light, citizen szience, crowdsourcing

Soon, citizen science could become a usual method of data collection in heritage and historic environments. Technological developments are driving a surge of academic interest in the topic. The wide availability of smartphones and tools to share and process images are making citizen science more and more accessible. There have been successful projects outside the heritage domain, for example in the monitoring of species distribution or coastal erosion. Recent scientific research has focused on determining the quality of measurements processed by citizen scientists, in particular the quality of data extracted from images.

This presentation will focus on the viability of citizen science approaches to measure indoor air quality. This can be achieved by taking advantage of indicators of indoor air quality that change in color. For example, dust deposition on white surfaces results in a homogeneous darkening of the surface. The corrosion of lead coupons, as used in the Oddy test, results in different types of visual change (such as pitting or homogeneous darkening). Light doses are commonly assessed using dosimeters such as blue wool, which display gradual color changes. The presence of acids can be visually assessed using A-D strips.

The challenges of using dosimeters to measure changes in these indicators are many. Firstly, we need to solve a metrology question: the quality of the data and its dependence on experimental factors needs to be measured in comparison with reference techniques. Secondly, there are problems of data analysis: the submitted images need to be post-processed, corrected, and calibrated before data is extracted. Finally, there are issues of visitor engagement and participation: experimental design needs to consider the way visitors will interact with the study and the patterns of participation (frequency, number and regularity of the submissions).

My team has investigated this by conducting experiments in indoor and outdoor sites, as well as in controlled conditions, where visitors have been prompted to contribute pictures and submit them online. We have assessed changes of color and area, under changing conditions of light and position of the participants. We have also investigated different ways to collect and post-process images, from manual analysis using Photoshop to automated analysis using machine vision and segmentation analysis.

Our findings indicate that smartphone photography could be used to assess with high sensitivity some changes. For example, it is as good as a colorimeter at measuring changes in lightness (i.e particulate matter deposition), but it is less precise in other color coordinates. Our experience setting up citizen science experiments in tenths of locations, indoors and outdoors, popular and remote, large and small, can inform future experiments in the area. The lessons from this experience help us outline a blueprint for the future of citizen science projects in indoor air quality in heritage.

Notes:

IAQ 2020

Posters

Measurement of Indoor Air Quality for Cultural Institutions with Moderate Resources

J. Sainato[1]

1 *Center for Jewish History, 15 West 16th Street, New York, NY 10028*

Correspondence: *jsainato@cjh.org*

Keywords: collection care, monitoring, urban environment

Housed together, the combined collections of the five Partners that make up the Center for Jewish History (the Center) constitute the largest repository of Jewish History in the United States. Preservation and access are at the core of the collective work of the Center, its five Partner institutions and their missions. We believe that it is not enough to merely provide virtual access to the more than 100 million documents, 500,000 books, and thousands of art objects, textiles, ritual objects, music, films, and photograph via digital surrogates: we need to maintain our collections in a state that allows users to touch, smell, and interact with their heritage.

In 2018 the Center's Werner J. and Gisella Levi Cahnman Preservation Laboratory decided to add indoor air pollution testing to their already robust environmental monitoring program. The purpose of the tests was to 1) determine the extent to which our building envelope and filtration system are protecting collections from the outdoor, urban environment; 2) monitor the health of our collections by measuring the level of gases created by ongoing chemical deterioration; 3) create a base-line of indoor pollutant measurements as a way to alert us to future problems and evaluate the success of mitigation efforts.

Working with the guidance of engineers and scientists from other institutions in the area already performing indoor air quality testing, the Center is now routinely monitoring seven sites in our collection storage areas (and will expand to ten sites in 2020). Our experiences using different monitoring systems and struggling to make sense of the test results offer a practical guide to other moderately sized research institutions without a large technical support staff who want to add IAQ to their collections care metrics.

Notes:

Monitoring the environment surrounding Hasan's cloak: a case study

E. Menart[1,2], D. Knez[1], I. Kraševec[3], M. Strlič[3] and I. Kralj Cigić[3]

1 *National Museum of Slovenia, Prešernova cesta 20, 1000 Ljubljana*
2 *Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana*
3 *Faculty of Chemistry and Chemical Technology, University of Ljubljana*

Correspondence: *eva.menart@nms.si*

Keywords: pollutants, VOCs, monitoring, composite object, display case

Hasan's cloak is one of the most important objects in the collection of the National Museum of Slovenia. This chasuble was made from the Turkish cloak of Hasan Pasha, who fell in the Battle of Sisak in 1593. It was used for mass for many years, especially on St Achathius Day, in memory of the victory over the Turks and has been a part of the Museum's collection since 1931. The chasuble is made of silk with silver thread and is currently being displayed in the newer museum building, built in 2008. The building is located in central Ljubljana, in close proximity to the main train and bus station and several roads, and equipped with climate control and graphite-based air filtration. However, the actual conditions inside the building have so far not been evaluated.

In the frame of the Horizon 2020 APACHE project (Active & intelligent PAckaging materials and display cases as a tool for preventive conservation of Cultural HEritage) monitoring of several pollutants is being carried out in display rooms and display cases as well as in storage rooms and boxes or drawers. Due to the importance and sensitivity of this composite object, several monitoring campaigns will be carried out in its display case, which will enable us to evaluate how appropriate the case is in terms of object protection and preservation, and if additional preservation measures are required (e.g. stricter T and RH control, pollutant adsorbents etc.). In addition to T and RH, both indoor- and outdoor-generated pollutants will be monitored, namely formaldehyde, formic and acetic acid, NO_2, SO_2, O_3 as well as tVOC and H_2S.

Monitoring will be carried out four times over the course of one year to detect any seasonal changes in pollutant concentrations. The results will provide valuable information on the conditions inside the building, air-tightness of the display case and possible harmful emissions from materials it contains, and also offer insight into realistic conditions in medium-sized heritage institutions, crucial for further research in the frame of the APACHE project.

Acknowledgements:
Financial support of the European Union's Horizon 2020 research and innovation programme (grant agreement No 814496) and the Slovenian Research Agency (research core funding No. P6-0283 and P1-0153) is gratefully acknowledged.

Notes:

How environmental pollution affects modern paints: The influence of UV-light, sulfur dioxide and RH

L. Pagnin[1], R. Wiesinger[1] and M. Schreiner[1,2]

1 *Institute of Science and Technology in Art, Academy of Fine Arts Vienna, Schillerplatz 3, 1090, Vienna, Austria*
2 *Technische Universität Wien, Institute of Chemical Technologies and Analytics, Getreidemarkt 9/164, 1060, Vienna, Austria*

Correspondence: *l.pagnin@akbild.ac.at*

Keywords: gaseous pollution, UV-light, degradation, acrylic, alkyd

Nowadays, the control of indoor museum environments for the prevention and conservation of artworks is important in order to slow down the deterioration of objects. The main goal is to achieve the stability of the indoor climate, where relative humidity and temperature are maintained at adequate values [1, 2]. However, even gaseous pollution and solar radiations contribute to further degradation effects on materials. The different concentration levels of these two factors found in museums are often linked to those of outdoor pollutants. Therefore, understanding the degradation mechanisms that affect artworks exhibited outside would lead to an extensive knowledge of their effects even on indoor materials [3]. Over the years, the effects of pollutants on different historical art materials have already been studied [4-6]. However, analysis and investigation of the stability and the chemical and physical behavior of modern materials (such as polymeric binders and inorganic/organic pigments) are still of interest. The way in which a pollutant interacts with a polymer is unique and changes according to the different manufacturing preparation of the product (such as the presence of additives) but also to the different pigments added to the mixture.

To this purpose, in this study, environmental conditions of accelerated outdoor aging were reproduced by using a UV and gas chamber. The samples under investigation are paint mixtures of two different binding media (acrylic and alkyd) with three inorganic pigments (artificial ultramarine blue, chromium oxide green, and cadmium yellow). For UV-light aging, the samples were aged for 168, 336, 504, 672, 840, and 1008 h, respectively. Gas aging was performed using sulfur dioxide (SO_2) with a concentration of 15 ppm; the value of relative humidity (RH) chosen was 80% for a total of 168 h gas exposure. This study focuses on the application of the 3D microscope for the evaluation of surface degradation, taking into account how SO_2 and UV-light aging differ in terms of morphological change (crack formation, increase in roughness, glossy decrease, etc.). In addition to this technique, Fourier-Transform Infrared (FTIR) analysis to understand the molecular changes and colorimetric measurements for considering the colour variation (ΔE) between unaged and aged samples were performed.

This preliminary overview of the results obtained will allow understanding how to discriminate the different morphological structure of the paints to the surface, and how the chemical/molecular modifications change depending on (I) the UV exposure over time and (II) the percentage of relative humidity combined with the concentration of the pollutant gases. In addition, the study will solve some conservation-restoration problems occurring in real practice, such as the cleaning strategies of surfaces from degradation products and possible protectives that can be applied to outdoor artworks [7].

References

[1] D. Thickett, Studies in Conservation, 63(2018):262-267.

[2] J. Watt, J. Tidblad, V. Kucera, R. Hamilton, The Effect of Air Pollution on Cultural Heritage, (2009):1-27.

[3] D. Naldzhiev, D. Mumovic, M. Strlic, Building and Environment, 106559(2019).

[4] B. Graue et al., Environ Earth Sci, 69(2013):1095-1124.

[5] P. Storme et al., Herit Sci, 3(2015):1-15.

[6] A. Alebic-Juretic, D. Sekulic-Cikovic, Studies in Conservation, 54(2009):49-57.

[7] V. Gomes, A. Dionísio, J. S. Pozo-Antonio, Science of the Total Environment, 625(2018):233–245.

Notes:

Experiences with indoor generated air pollutants in the Weltmuseum Wien: The reinstallation of the collection as a chance to improve preventive measures?

S. Stanek[1], M. Griesser[1], V. Pitthard[1], S. Mendez [2] and C. Jordan [2]

1 *Kunsthistorisches Museum Vienna, Conservation Science Department, Burgring 5, 1010 Vienna, Austria*
2 *Weltmuseum Wien, Conservation Department, Heldenplatz, 1010 Vienna, Austria*

Correspondence: *sabine.stanek@khm.at*

Keywords: building refurbishment, material emission, VOC monitoring, hazing on glass

The *Weltmuseum Wien, WMW* (formerly named *Museum für Völkerkunde, MVK,* which translates as *Museum of Ethnography*), is a world known museum with an extensive ethnographic collection. It is situated in the historic building complex of the Hofburg Palace since 1928. Due to a necessary redesign of the permanent collections and a comprehensive renovation, the building was closed for the general public in 2001. In 2007, one floor was re-opened partly for special exhibitions.

The rest of the building was renovated and refurbished extensively from the ground to top floor: the replacement of entire electric and security systems, the extension of conservation labs and office spaces and the re-equipment of storage areas; last but not least the rearrangement of galleries including the construction of new and the adaption of already existing showcases. After the completion of this enormous endeavour, the museum was entirely re-opened in late 2017.

For successfully implementing this large project, a multidisciplinary approach was chosen when discussing preventive conservation measures. One focus was put on IAQ inside the galleries, with special emphasis on the construction of both new and historic showcases. To protect the valuable mixed-media objects mitigation strategies for indoor generated pollutants were developed. General guidelines for material selection for a wide range of commercial products were set, abandoning the ones already known to be problematic. Furthermore, all display materials were tested for their suitability in advance to minimize their offgassing.

Nonetheless, first investigations of the new showcases proved their VOC levels no to be in the expected and acceptable range. Preventive measures to protect the historic ethnographic objects from potential harmful emissions were taken immediately and ongoing VOC monitoring was implemented.

Shortly after finishing the major museum renovation another problem occurred: It was noticed that the glasses of many display cases showed a fogging on the surface, the hazy film sometimes developing in specific patterns. Though a targeted cleaning campaign the fogging was only temporarily removed, it reappeared after a short period again. Further analytical investigations were carried out using gas chromatography-mass spectrometry (GC-MS) to identify the compounds responsible for the fogging effect. In parallel, investigations were performed together with the responsible-conservators and the facility management to identify und understand the source/s of this effect. For presenting the newly installed permanent exhibition to the public unhindered, it was a matter of extreme urgency to find an appropriate long-term cleaning method.

Notes:

Using oak (*Quercus Sp.*) as a natural, complex source of volatile organic compounds to study corrosion of lead metal in multi-year laboratory experiments

J. B. Crawford[1]

1 *Sustainable Microclimates Ltd, Birmingham Science Park Aston, Birmingham, West Midlands, B7 4BB, United Kingdom*

Correspondence: *james@sustainablemicroclimates.com*

Keywords: oak, volatile organic compounds, acetic acid, corrosion, lead

Emissions of volatile organic compounds – especially acetic acid – by oak (*Quercus Sp*.) and some other woodworking materials are notorious for their aggressive corrosion of lead metal artefacts inside poorly ventilated heritage environments e.g. showcases, pipe-organs. For those oak materials valued for their own heritage significance or appearance, their segregation, or blocking of their VOC emissions with metallicised films is not an option. Remaining mitigation options include filtering, sorbing or venting concentrated VOCs, and/or by protecting lead surfaces with coatings or corrosion inhibitors. To research effectiveness of candidate mitigation actions, laboratory experiments create samples and atmospheres to imitate artefact materials and heritage environments.

The presented work was motivated by doubts about the veracity of the literature on the theory of VOC corrosion of lead since it largely comprises secondary sources supplemented by results from short experiments that generally used few and synthesized VOCs, with high relative humidity (100%) and temperatures (40-60°C).

To advance knowledge on the morphology and chemical composition of lead corrosion products in heritage environments, the presented laboratory experiments used a natural *cocktail* of VOCs emitted by oak for up to 5 years, and using conditions (≤76% RH and 10-25°C) similar to indoor environments found in some historic buildings in temperate climates. Figure 1 shows a close-up of one of the deployed saturated salt solution test cells.

Plan and cross-section observations by optical and scanning electron microscopies of lead samples after 4½ and 5 years of oak-VOC exposure revealed a voluminous – yet compact – morphology of corrosion products. These resemble published samples extracted from lead artefacts that had been exposed in heritage environments for decades to centuries. Moreover, the resulting corrosion morphology differed greatly to the very porous corrosion product layers made by others [1] in a laboratory over three weeks using synthetic acetic acid and cycling between ambient RH and 100% RH.

A fixed, small angle of incidence and slow angular scans of the lead samples (exposed with oak for 3 months and for 2¼ years) with a high-resolution X-ray diffractometer revealed trace to minor amounts of β-lead monoxide, normal lead acetate, and water-soluble and water-insoluble lead acetate oxide hydrates; together with greater and increasing amounts of lead oxide carbonate hydroxide and lead carbonate hydroxide. The seventh detected phase matches an unknown crystalline phase found by others on a Dutch pipe-organ comprising oak; further substantiating the relevance of this laboratory work to real indoor heritage material-environments.

The presentation will highlight that the undertaken laboratory method of corroding lead with oak-VOCs, for long durations, followed by particularly configured high-resolution X-ray diffraction, was instrumental in generating a more comprehensive, evidenced portrayal of this problematic heritage material-environment than other laboratory methods have done. For instance, its detection of the:

- seven crystalline phases totaled two more than those detected by the two nearest methods [2,3] combined
- two soluble acetates of lead backs up with proof a previously unevidenced assertion[2] of their vital roles in the VOC corrosion of lead.

Fig. 1: Frame from 2¼-year timelapse video (https://www.youtube.com/watch?v=28jxnee1IAc) macroscopically documenting corrosion of lead by oak-VOCs

References

[1] Rocca, E., Rapin, C., Mirambet, F., Corrosion Science, 46 (2004) 653-665

[2] Niklasson, A., Johansson, L.-G., Svensson, J. E., Corrosion Science, 50 (2008) 3031-3037

[3] Grayburn, R., Dowsett, M., De Keersmaecker, M., Westenbrink, E,; Covington, J. A., Crawford, J. B., Hand, M,, Walker, D., Thomas, P. A., Banerjee, D., Adriaens, A. Corrosion Science, 82 (2014) 280–289.

Notes:

Berardo Museum: a preliminary investigation of VOCs inside display case with contemporary painting

K. Barbosa[1], Teresa Ferreira[2], E. Vieira[1] and P. Moreira[1,3]

1 *Research Centre for Science and Technology of the Arts, CITAR, Universidade Católica Portuguesa, Porto, Portugal*
2 *Chemistry Department at the Science and Technology School & HERCULES Laboratory, University of Évora, Évora, Portugal*
3 *Centre for Biotecnology and Fine Chemistry, CBQF, Universidade Católica Portuguesa, Porto, Portugal*

Correspondence: *kcristine@yahoo.com*

Keywords: VOC, museum, acrylic case, passive sample device, contemporary painting.

Within their conservation proposal many museums usually protect their paintings with glass or acrylic during exhibition, loans and in storage. However not uncommon changes in museum objects caused by pollutants in micro and macro environment are detected. The actual proposal is to encourage the practice of monitoring gas pollutants inside museum environment as a relevant tool for preventive conservation. While some museums use microclimate frames to protect paintings against pollutants, to provide climate buffering and to protect paintings from vandalism, most museums in Portugal use frontal glass or acrylic case as the main proposal to protect paintings from vandalism and from the visitors touch. Generally for most museums, pollution damage only becomes relevant when the damage is detected.

A contemporary painting protected by an acrylic box from Berardo Museum, a modern and contemporary art museum located in Belém, Lisbon, near to Tejo river was chosen as a case study. The objective of the research was to understand how was the air quality inside the display case comparing with the gallery room environment. The painting is made of wood and metal reliefs painted, fixed with screws in an old wood frame. According to bibliography [1, 2 and 3], the materials from this painting are probably a source of harmful volatiles compounds although the museum had never reported any alteration inside the vitrine that could be attributed to gas pollutants. The acrylic display case was constructed by the museum to avoid visitors to touch in metal reliefs that in the past damaged the artwork.

Measurements were done inside and outside vitrine using passive samples devices from IVL Swedish Environmental Research Institute for their reliability, user-friendliness and quick results. Diffusive samplers were exposed during 28 days and SO_2, HCl, HF, acetic acid and formic acid were analysed. Tenax TA was used as a solid adsorbent for volatile organic compounds (VOCs) and was exposed during one week according to the supplier's instructions. The temperature and relative humidity were also measured with Testo 174H data loggers.

The results showed that the concentration of acetic and formic acids were higher inside than outside the acrylic case and that the total of volatile organic compounds (TVOCs) was higher in the exhibition gallery than inside the vitrine. This paper will present the results and comparisons between the concentration levels inside and outside vitrine, the evaluation of the risks of the acrylic cases when related to VOC - induced damage and discuss the relevance of monitoring gases pollutants even when damage has not been detected yet.

References

[1] C. M. Grzywacz. Monitoring for Gaseous Pollutants in Museum Environments. Getty Publications - Tools for Conservation. Los Angeles: Getty Publications, 2006.

[2] P. Hatchfield, J. Carpenter. Formaldehyde: How great is the danger to museum collections? Harvard University Art Museum, 1987.

[3] A. Schieweck. Airborne Pollutants in Museum Showcases: Material Emissions, Influences, Impacts on Artworks. Ph.D. Thesis, 2009. Available at https://www.hfbk-dresden.de/fileadmin/user_upload/Downloads/Lehre-Forschung/Studiengaenge/Restaurierung/Diss/Diss_Schieweck_2009.pdf (accessed 12/03/2018).

Notes:

Pneumatic cleaning of books and manuscripts

L. Mašková[1], J. Smolík[1] , L. Ondráčková[1] , J. Ondráček[1], M. Fedinová[2], V. Jandová[1], P. Vávrová[2] , M. Součková [2] and J. Neoralová [2]

1 *Institute of Chemical Process Fundamentals of the CAS, Rozvojová 135, 165 02, Prague 6, Czech Republic*
2 *National Library of the Czech Republic, Klementinum 190, 110 00, Prague 1, Czech Republic*

Correspondence: *maskova@icpf.cas.cz*

Keywords: two-phase spray, carbon dioxide, snow particles

The main goal of the project "Research and development of advanced techniques of cleaning of books and manuscripts" (No. DGP02OVV048), supported in 2018-22 by the Ministry of Culture of the Czech Republic, is to develop advanced techniques suitable for restoration of library and archival collections. Dry cleaning equipment may consist of brushes, erasers, vacuum cleaners or compressed air. However, predominantly only coarse particles are removed by these methods. Gas flow alone cannot generate sufficient forces to overcome adhesive forces and remove submicron particles. Two-phase spray contains carrier gas stream (nitrogen) with carbon dioxide snow particles. The stream strikes a contaminated surface. Resulting physical and chemical interactions lead to particulate and organic contamination removal [1]. The collision of carbone dioxide particles transfers momentum from the snow to the surface contaminant and can overcoming the adhesive forces.

Preliminary results showed that nitrogen gas flow blew out coarse particles but residues of nanoparticles remained. The sample cleaned by carbon dioxide snow particles in nitrogen carrier flow contained less amount of nanoparticle residues. In addition, no significant damage of the cellulose-based paper was observed after cleaning by both methods.

References

[1] R. Sherman, Sci. Technol., 25 (2007) 37 – 57.

Notes:

The National Museum of Brazil and the absence of national safety regulations for museums and its cultural goods: the tragedy

Anny Falcão[1]

1 *Faculty of Post-Graduation in Juridical Sciences of Federal University of Paraiba, UFPB, Brazil (Jardim Cidade Universitária Street, João Pessoa, PB, zip code: 58051-900, Brazil. Phone number: +55 83 3216 7622)*

Correspondence: *annyvf@hotmail.com*

Keywords: national museum of brazil; air quality; high temperature; regulation.

The day was in September 2018. Brazilians were surprised by the blazing fire that didn't cease to burn years of brazilian and world history that burned together with the bicentennial construction of the National Museum of Brazil in the city of Rio de Janeiro, although no human victims. All asked: would it be the deficiency of inspection of the operating permits, would it be scarce of public budget to maintain the structural safety of the historic building or is its insufficient planning for air quality and the apparatus that provide this for the conservation of the museum's collection? After seven months of investigations, the Brazilian Federal Police diagnosed that the fire was caused by a high temperature due to a short circuit in the cooling system, because three air conditioners were connected to a single circuit breaker that overheated and caused the burn of the entire collection.[1] Experts found that the extinguishers were working but there was no wall hydrants, neither sprinklers (automatically activated showers in case of smoke) or fire alarm.

The brazilian safety standards, such as NR 10[2], deal with the safety of people in buildings and are enforced by the Brazilian authorities, but a specific rule for the security of museum collections needs to be built for the brazilian situation, a tropical country with high annual temperatures and different humidity states, which explains the specificity of brazilian's museums. International standards, such as the North American NFPA 209[3] can serve as inspiration, however, brazilian weather conditions should be considered. This situation evidenced the lack of regulations and also an absence of a program for high temperature emergency situations and security of the cultural goods at the National Museum of Brazil led to the loss of the collection and the burn of the museum's historic building. By now, a protocol of intent to build a risk program is being prepared by United Nations Educational, Scientific and Cultural Organization -UNESCO, the Brazilian Development Bank, Vale Foundation and the Federal University of Rio de Janeiro.

References

[1] FERNANDES, A. Report points to oçςaclverload in air conditioning and electrical system failures as causes of the fire of the National Museum. Pesquisa Fapesp, vol. 272 (2018) page 57 – 58 ISSN 1519-8774

[2]BRAZIL, ABNT - Associação Brasileira de Normas Técnicas NBR 10 - SAFETY IN ELECTRICITY FACILITIES AND SERVICES - June of 1978.

[3]UNITED STATES OF AMERICA. NFPA – National Fire Protection Association - Code for the Protection of Cultural Resource Properties – Museum, Libraries, and Places of Worship – 2017 edition.

Notes:

Semi-quantitative GCMS-based thermal desorption to examine and limit the risk of volatile organic compounds to collections

K. Stoneburner[1], E. Monroe[1] and F. France[1]

1 *Library of Congress, 101 Independence Ave SE, Washington D.C., 20540-4560*

Correspondence: ksto@loc.gov

Keywords: material emissions, pollution monitoring, mitigation

Collection item's housings and the materials used in the construction of storage areas often release volatile compounds that can present certain risks to collection items. In addition, as collection materials age, they degrade and often release particular odours, where the concentration and identity of these compounds can serve as an indicator of a collection's preservation needs. Some of these off-gassing compounds can accelerate not only the degradation of the object itself but also nearby collection objects. Based off of thermal desorption gas chromatography mass spectrometry we have developed several techniques for analysing the off-gassing of collection objects, housing materials, and construction materials. These techniques include direct thermal desorption of samples and field air sampling through the use of characterized sorbents and battery powered pumps. Compounds are desorbed from samples or the sorbent onto a cooled inlet prior to separation by gas chromatography then detected via mass spectrometry and as this is a closed system the results are semi-quantitative upon comparison to an internal standard. Together these two techniques allow for characterization of both the materials and air within a collection space or housing. This characterization allows for better understanding of the level of risk various materials may cause to collections before they are used as well as assessment of the state of established collection housings and spaces. These results then allow for preventative mitigation and assist in informing which mitigation strategies would be most appropriate for existing collection spaces and housings. This work will detail the methodologies and parameters used and illustrate through several case studies how this testing regimen has assisted in understanding the current state of degradation, potential risks to the Library of Congress's collections, and informed for the selection of appropriate mitigation techniques.

Notes:

Monitoring collection spaces in a structured and automated way: two test cases in Belgium

Geert Bauwens[1], Estelle De Bruyn[2], Laura Debry[2], Staf Roels[1]

1. *Building Physics Section, Department of Civil Engineering, KU Leuven, Kasteelpark Arenberg 40, bus 2447, 3001 Heverlee*
2. *Royal Institute of Cultural Heritage, Parc du Cinquantenaire 1, 1000 Bruxelles*

Correspondence: geert.bauwens@kuleuven.be

Keywords: software, monitoring, light, environment, storage

By monitoring the indoor environment, we can evaluate whether the environmental conditions are suited for the collection's preservation, and whether or not actions made to improve them are actually delivering on their promise. In the past, simplified universal standards tended to be promoted. But more recently, conservators prefer to map, understand and address the specific needs of the collection, their materials and the particular context in which the collection is housed [1]. Traditionally, measurements are generated by standalone loggers in a limited number of spaces, with significant lead time between performing the measurements and doing the actual reporting. A real-time, structured and automated monitoring can provide a detailed overview of the environmental conditions and serve as an effective decision support tool to help conservators take informed decisions.

For several years now, the KU Leuven Building Physics Section is developing an online software platform to help conservators monitor the potential risk the environment poses to the stored collection. In this paper we present two test cases, the Abbey of Grimbergen and the van Buuren Museum in Uccle, Brussels. They house objects that range from furniture, paintings, tapestry to very valuable books. In both of them, we measure temperature, relative humidity and light exposure. They thus provide two real-life storage environments to test run our current software prototype. In this paper, we focus on three aspects.

First of all, we aim to identify potential roadblocks in the use of the software. Through the software we collect data from on-site sensors in a structured way, analyse the data, inform our monitoring with a digital notebook, and evaluate whether we adhere to the preventive conservation requirements posed by the collection.

Second, as a proof of concept, we aim to investigate the possibility to upload floor plans and then annotate them in a specific way. For instance, we might want to document in detail collection spaces, keep track of where exactly we placed our sensors, communicate about our monitoring with colleagues, or even to have the software automatically annotate zones based on analysis results. Third, we aim to implement an automated light study that adheres to the widely adopted ISO Blue Wool Standard [2]. We aim to automatically link this standard with measurement data and with parameters that the user defines, e.g. desired lifetime of object and percentage of time exposed to measured light conditions.

References

[1] N. Putt, S. Slade, Teamwork for preventive conservation (2004), p. 24

[2] S. Michalski, Agent of Deterioration: Light, Ultraviolet and Infrared, Canadian Conservation Institute's web resource (2018), s.p.

Notes:

IAQ 2020

Inspirational day

Indoor air quality for heritage objects and human health: just a different interpretation of the same measurements?

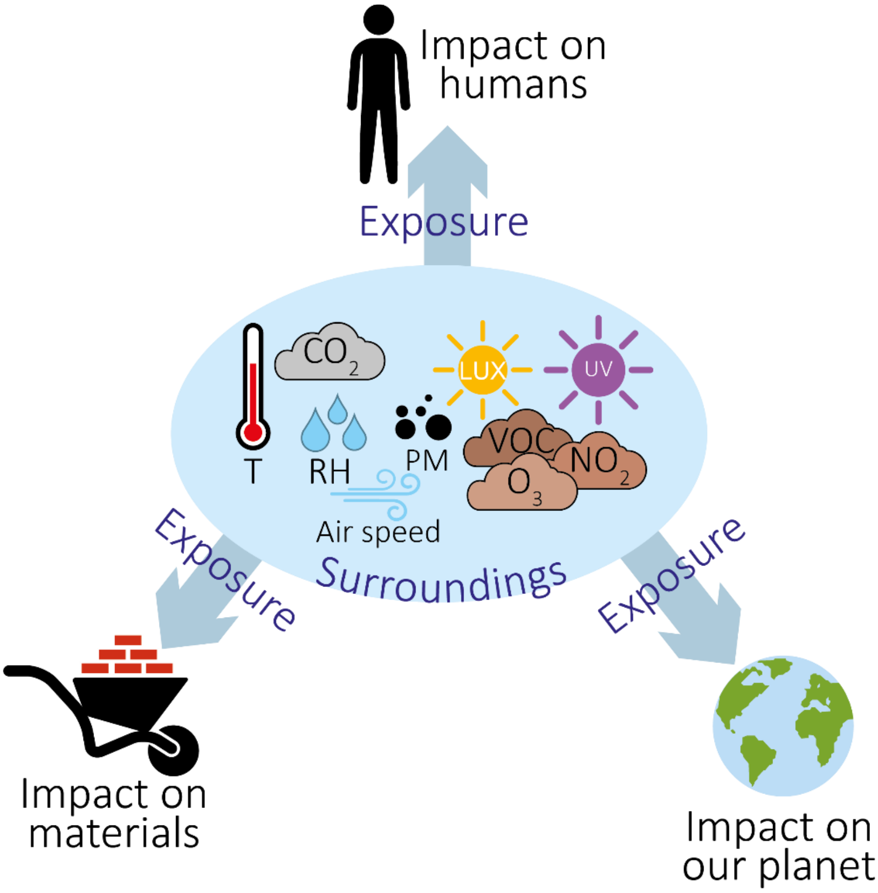
Olivier Schalm[1,2] and Gustavo Carro[2]

1. *ARCHES, Conservation Studies, University of Antwerp, Blindestraat 9, B-2000 Antwerp, Belgium*
2. *Antwerp Maritime Academy, Noordkasteel Oost 6, 2030 Antwerpen, Belgium*

Correspondence: *olivier.schalm@hzs.be, gustavo.carro@hzs.be*

Keywords: air quality, degradation, human health, thresholds

We have monitored several environmental parameters in a restoration studio for paintings. However, such measurements are complex and can be overwhelming. For that reason, guidelines, norms and legislation can be used to convert such data into a single risk index that is easy to read. But what happens when the same time series is processed with such methods dedicated to the 'health' of paintings and to the health of 'humans'? And finally, what is the meaning of air quality?



Notes:

How to tackle complex problems such as improving the experience and preservation conditions in museum rooms using design thinking?

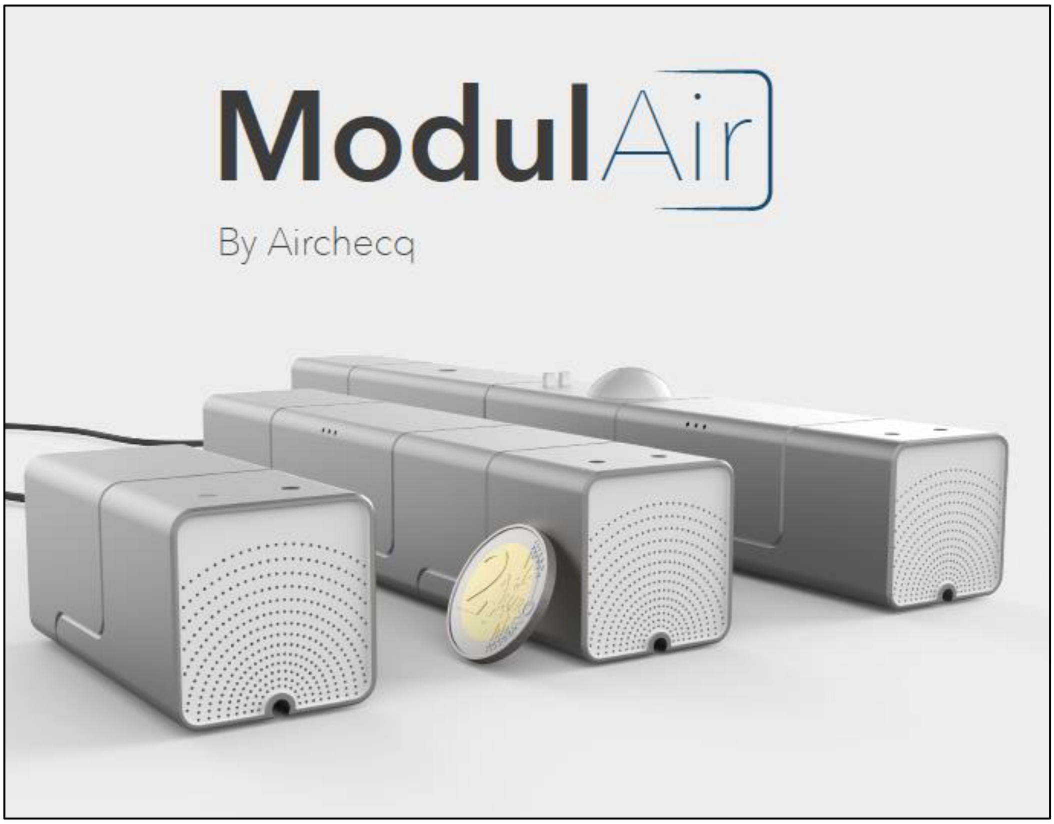
Kristof Vaes[1]

1. *Design for Interaction – Design for health, Faculty of Design Sciences / Product Development, University of Antwerp, Ambtmanstraat 1, 2000 Antwerpen, Belgium*

Correspondence: *kristof.vaes@uantwerpen.be*

Keywords: Design for wellbeing, Care Technology, Strategic design, Interaction Design

Mitigation actions are sometimes needed to improve the preservation conditions of heritage objects. However, the implementation of such mitigation actions can change the experience of the visitor. Such changes are not desired by everyone. Complex problems with conflicting goals and a multitude of stakeholders' opinions can delay decision making. Design thinking is a creative thinking process to solve such complex problems by involving all stakeholders. This presentation will give an insight in the basics of design thinking. The method will be illustrated with several examples in the heritage field and in the domain of respiratory problems.



Notes:

How to communicate scientific data to non-experts by using visual communication as a universal language?

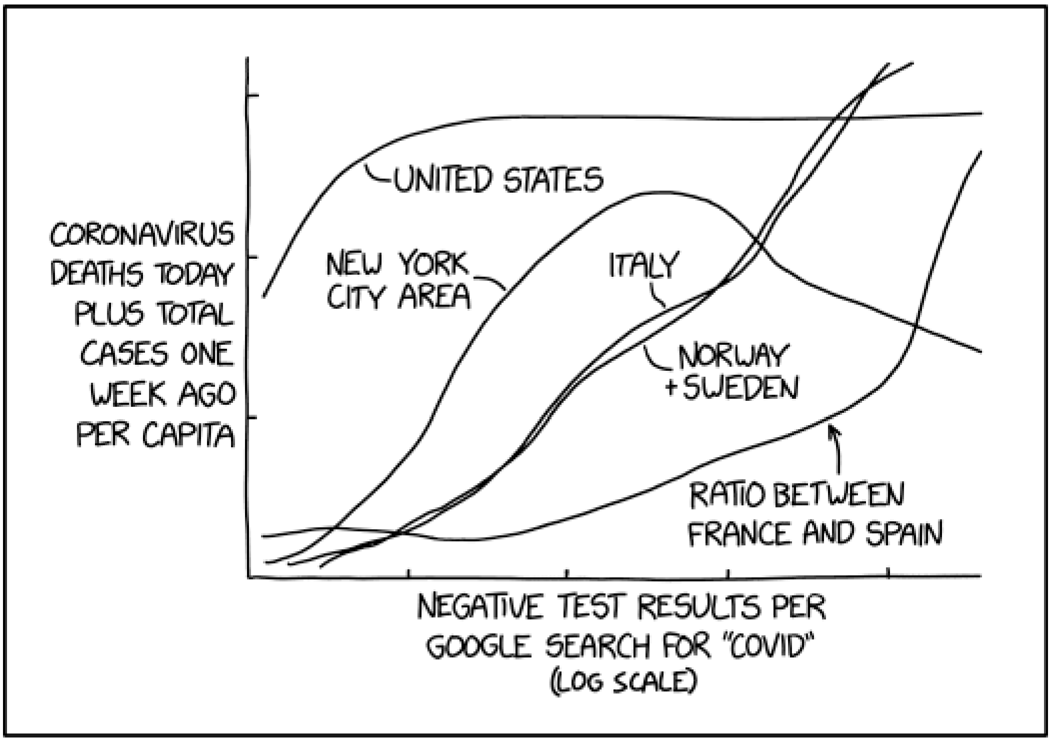
Geert Potters[1] and Marjolein Vanoppen[2]

1. *Antwerp Maritime Academy, Noordkasteel Oost 6, 2030 Antwerpen, Belgium*
2. *Ghent University, Chair Industrial and Circular Water Technology*

Correspondence: *geert.potters@hzs.be, marjolein.vanoppen@ugent.be*

Keywords: infographics, Interpretation of visuals, Science communication

As scientists, we prefer in-depth data processing methods and detailed visualisations (never mind complex models to accompany them), and we rely on years of training to deal with the uncertainty of the outcomes. The end users of the data, however, are often active outside of the scientific world, and while they are open to use the insights of these scientists, for management of policy development, they are often not equipped or trained to deal with this complexity or uncertainty. To close the gap between both worlds, we often rely on infographics and data dashboards. These instruments could often stand some improvements. The presentation will analyse several examples of how information should and should not be presented, to make science serve the needs of society better.



I'M A HUGE FAN OF WEIRD GRAPHS, BUT EVEN I ADMIT SOME OF THESE CORONAVIRUS CHARTS ARE LESS THAN HELPFUL.

Notes:

Alternative designs for the energy and climate needs of heritage objects and humans

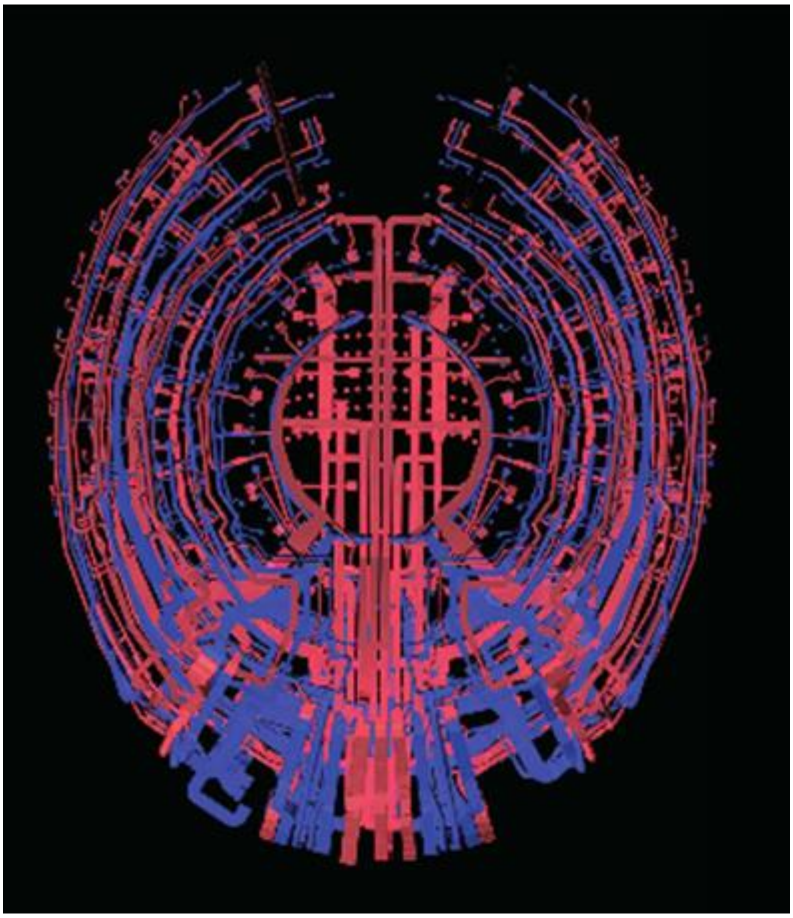
Johan Van Rompaey[1]

1. *Faculty of Design Sciences, department of Architecture, University of Antwerp*

Correspondence: johan.vanrompaey@uantwerpen.be

Keywords: energy, buildings, people, air quality

Numerous museums are housed in huge, historical buildings that do not fulfil the contemporary building requirements. Maintaining proper climatic conditions for heritage objects and human well-being result in large energy costs, a substantial ecological footprint and a strong dependency on complex technology. Several conventional solutions (e.g., isolating the building envelope, improving the acclimatization system, generating renewable energy) aim to reduce the mentioned problems. However, it is not always clear if these conventional solutions are the answer to the mentioned problems. We have to think out of the box and come up with new solutions for our old buildings.



Notes: