Ten Agents of Deterioration as a framework for KIK-IRPA’s preventive conservation projects

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Introduction

Preventive conservation comprises all measures and actions that aim to avoid and to minimize future deterioration of an art object or a heritage collection. To determine which actions are needed, it is necessary to define the hazards, i.e. the sources of potential harm. To go through these in a systematic manner, the concept of the Ten Agents of Deterioration was developed as a major framework for preventive conservation. Stefan Michalski first proposed nine agents: incorrect relative humidity, incorrect temperature, radiation, contaminants, pests, physical forces, criminals and vandals, fire, and water. Robert Waller added a tenth: custodial neglect, or dissociation. The ten agents can be divided into “sudden” agents that are catastrophic in nature, such as fire, water (flooding), physical forces (major earthquakes) and vandals. These can provoke a drastic effect on museum objects and collections. Other agents are rather “slow” and generate cumulative damage, leading to a loss of value of the artwork and collection by slow degradation processes (e.g., radiation, incorrect relative humidity). The human factor is crucial where agents such as criminals and vandals are involved, and also for dissociation, and of indirect influence for others.

Frameworks such as the Ten Agents of Deterioration are systematically used in risk analyses, mainly in the risk identification step, and they are considered as the starting point for any project in the Preventive Conservation Unit of KIK-IRPA. To be put into practice, this framework requires a flexible team with people from various backgrounds combining their knowledge, collaborating with people of diverse fields of expertise, and achieving results by working on a wide range of missions, requiring at once sharp scientific methodology and quality social interactions. To illustrate the framework, several recent projects of the Preventive Conservation Unit are discussed, each focusing on one or more of the agents. This overview demonstrates de facto the multidisciplinary approach of the preventive conservation profession. For each presented project, a small general introduction is provided for the agent involved, while more detailed information can be found elsewhere.

Incorrect temperature: Saving KIK-IRPA’s photographic collection by SOS Negatives and NE-ORG

The “incorrect temperature” agent of deterioration subdivides into three main categories; (1) Temperature fluctuations that result in a (limited) expansion and shrinking of the material. Given the correlation between temperature and relative humidity, these fluctuations have a significant impact on composite objects consisting of materials with different expansion

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1 Michalski 1990, p. 591.
2 Waller 1994, p. 12.
3 Pedersoli, Antomarchi and Michalski 2016, p. 53.
coefficients, such as multi-layered photographic materials; (2) Elevated temperatures that accelerate chemical reactions, as well as favour biological deterioration processes; (3) Low temperatures that can cause an embrittlement of certain materials. Lower temperatures, however, are generally beneficial for chemically unstable collections such as photographic supports.

KIK-IRPA possesses almost one million photographic objects, representing more than 120 years of heritage documentation on photographic carriers. This unique collection forms an extensive and precious illustration of the technical developments of the photographic medium since the end of the 19th century. Approximately 65% of the collection volume consists of recordings on glass plates and 35% of different types of plastic carriers. In terms of number, the latter group is the largest with around 600,000 items. The glass plate negatives represent the oldest part of the collection and, although relatively stable in chemical composition, they have physical disadvantages such as their weight, volume and fragility which make their use less practical than cellulose based supports such as nitrate and acetate. Around the 1930s the institution had completely abandoned the use of glass plates and favoured cellulose-based negatives. However, cellulose nitrate is unstable and, when in poor condition, presents an inherent hazard of spontaneous ignition (1–3). When this film type was systematically replaced in the 1950s by the more stable cellulose(tri)acetate, better known as the so-called safety film, a large part of the KIK-IRPA photographic inventory had already been carried out and the nitrate negatives remained an important part of the collection.

The degradation of nitrate film proceeds in various stages. (1) The film discolours towards an amber colour and fades. (2) The emulsion becomes softer, making it sticky. (3) Sticky and slimy blisters are formed between the support and the emulsion. The support completely discolours to a dark brown and is from then on very fragile. (4) The negative is reduced to a soft mass; stacked supports now form a “brick”. (5) In a final stage of deterioration, the sticky film reduces to brown powder. The risk of decay is amplified when both temperature and humidity increase, and it is highly influenced by the volume of unstable material – the more nitrate the higher the risk. Complementarily, the higher the amount of material, the more advanced the stage of degradation.

Until the end of the 1990s, KIK-IRPA regarded its collection of negatives mainly as a tool in the production of positive prints. Photographic negatives were stored in such a way that user comfort was paramount. The supports were preserved in separate boxes according to size: glass plates, cellulose nitrate sheet films, and the more stable cellulose(tri)acetate and polyester negatives were mixed. The storage space was conditioned around 20°C with an RH of 50%. Although common in paper archival contexts, such conditions are far from ideal for photographic supports and foster the decline of the nitrate supports. In 2011 it was discovered by chance that some of the nitrate films in the storage were in an advanced state of degradation: the negatives had become sticky and in most cases the image had become completely unusable. In addition, the deterioration increased rapidly: complete boxes of 50 negatives were affected by nitrate decay in less than 48 hours, without necessarily showing previous signs of damage. Urgent action was needed to prevent worse.

The first step in countering further degradation of the collection was to create a stable and better adapted climate in which the negatives were located. The Image Permanence Institute recommends the following values for the preservation of nitrate film: a maximum temperature of 2°C and a RH between 20% and 30%. Due to the mixed nature of the collection, its active use, and the limitations of the technical installation, it was impossible to achieve these values. A compromise has been reached of 33% RH and 13°C. To achieve the new storage conditions, the temperature was systematically reduced by 0.5°C per 48 hours, and several dehumidifiers slowly reduced the humidity level. At the same time, it was decided to manually check the nitrate series piece by piece. The main objective was the removal of contaminated film in order to counteract the auto-catalysing effect of the nitrate decay. At the same time, the primary and secondary packaging of the negatives was replaced by packages that passed the Photographic Activity Test (PAT). As a result, contact with various harmful substances, such as inks, was avoided in the future and the material was provided with a slightly alkaline buffer. This action also gave us insights into the conservation status of the collection. Since it was unclear which series were nitrate-containing, random sample surveys were carried out in consultation with the laboratories. Small samples of the negatives were taken for identification with infrared spectroscopy. The data obtained suggested that about 128,000 negatives had to be manually checked.

The objective of the “SOS Negatives project” in 2010-2011 was to focus on the conservation of the negatives and thus to carry out the evaluation and perform their reconditioning. During the study phase of the project it quickly became clear that evaluating...
After a few years, constant feedback during the working process and the discovery of very badly damaged negatives indicated the serious problem of climate. The “cold storage” project – initially suggested by Hilke Arijs – emerged again and made it possible to evaluate the measures and actions previously taken during the “SOS Negatives” campaign and in everyday collection management. As the process of decay was observed to be still ongoing on a part of the previously treated collection of negatives, Elodie De Zutter (digit) and Laura Debry (preventive conservation unit) worked together to update the collection analysis and rethink the climate and the physical organization of the space.

In order to considerably slow down the chemical degradation processes inherent to photographic materials (cellulose nitrate and cellulose acetate), the implementation of a cold storage system appeared to be essential. The collection of negatives not only suffers serious conservation problems, it is also confronted with a problem of storage space in certain areas of the current deposit room. It seemed only logical to attack both problems simultaneously by planning a global review of the storage space using the RE-ORG methodology: in 2017, the “NE-ORG: RE-ORG Negatives” project was born.

The objective of this project was to review the spatial organization of the KIK-IRPA negative repository. The different theoretical options for the physical reorganization of the repository were defined in function of the global or partial cooling of the negative storage. Balancing the advantages and disadvantages of different options whilst paying particular attention to fire safety, it will finally enable stakeholders (the Preventive Conservation Unit, but also the digitization team, the direction, the technical service and the “Régie des Bâtiments”) and management to choose the solution that best fits the needs and means of the institution.

By actively focusing on finding compromises between preservation standards, practice and sensitizing the staff to their own role in the conservation of our photographic heritage, we were able to safeguard an important part of our collection with modest means. Those projects are therefore an example that active and immediate intervention with available resources is indeed feasible, even in the case of a large collection. Now is the time to work on long term and extensive solutions for the risk mitigation of the entire negatives collection. In close collaboration with all the stakeholders, a structural and more permanent solution will be worked out.
Incorrect relative humidity: A big project to solve a big problem with big objects

The ambient humidity in a museum, historic building, storage area, showcase, etc. is measured in Relative Humidity (RH), which expresses the ratio, in percentage, between the weight of water contained in a given volume of air and the maximum capacity of that same volume of air at the same temperature and pressure. Generally, a relative humidity of less than 35% is considered as dry air, between 35 and 65% as moderately humid, and beyond 65% as humid air. Potential sources of humidity are numerous in the overall museum context: the air from outdoors, rain, excessive humidity in the soil, visitors’ perspiration, HVAC system and wet clothes, all combined with poor insulation of the building.

Degradation in heritage collections due to inadequate relative humidity (RH) can be physical, biological or chemical, depending entirely on the material properties of the objects. (1) Physically: any object made of materials containing a variable percentage of residual moisture will undoubtedly react to the amount of water present in the surrounding air in order to reach a hygroscopic equilibrium with its environment. In other words, the materials absorb and release moisture depending on humidity changes in the environment, and the variation of their moisture content causes a variation in their dimensions and mechanical stress. Objects composed of hygroscopic organic materials such as wood, leather, vegetal fibres or ivory, are therefore very sensitive to inadequate RH. (2) Chemically: humid air can generate corrosion on metal and other non-hygroscopic inorganic materials. A high RH accelerates also the chemical effects of UV rays on organic materials such as textiles, causing faster fading. (3) Biologically: excessive RH promotes the development of biological activity. The speed with which biological activity evolves also depends on the temperature and the culture medium.

To clarify this third type of degradation – biological attack – we describe below a specific part of a large and long-term project that started in 2012 and was completed only in 2018.

In 2012, the Preventive Conservation Unit was contacted by Train World Heritage - Railway History & Research, run by the National Railway Company of Belgium (NMBS/SNCB-Holding). Six historic carriages, owned by the Holding, were then stored in a semi-open work depot in Brussels [fig. 1-2]. A few years before, this depot had been declared unsafe and unusable by the fire brigade, as a result of which the heating and the lighting had been shut off and all work teams disappeared from the building. Further maintenance on the building and the rolling stock collection inside as well as visual inspections and controls were completely stopped. For fear of vandalism, the entrance doors of the six historic train carriages were completely locked so that unauthorized persons could not penetrate these valuable trains.

The six carriages were specially equipped for the royal journeys of Belgian kings. Carriages A1, A2 and B1 belonged to the royal train of King Leopold II and King Albert I and were built in 1901, 1905 and 1912. Carriage B1 was only manufactured in 1912 and was therefore only used by King Albert I. It consists of a luxurious salon, a small dining room, a kitchen, a storage room, a cloakroom and a toilet. The two other coaches are a salon and sleeper coach, and a conference and dining coach. The other three carriages 1, 2 and 3 were part of the royal train of King Leopold III and King Baudouin I. They were constructed in 1939 and are a salon coach, a sleeper coach and a conference- and dining coach. The interiors of all train coaches are particularly rich and have a particularly high national heritage value. These train coaches constitute a very complex type of heritage: large objects (railway coaches) containing small, often difficult-to-access object parts (compartments), with a multitude of different types of materials (wood, marquetry, paintings, textiles, glass, ceramic materials, metal, linoleum, plastic, Bakelite, rubber etc.). Today, two of the six royal carriages can be admired in the brand-new Train World Museum in Schaerbeek. But their way from the depot to this exceptional museum was difficult and long…

To solve a big problem with big objects, a big project was undertaken. Fféau and Le Dantec 2013, p. 10.

[Fig. 1] Train of King Leopold II/Albert I, coach A1, exterior, 1901. Working photo.
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[Fig. 2]
The interiors of two train coaches. 1901 (a), 1901 (b) and 1912 (c). Working photos.
The main reasons for the explosion of mould were:
- poorly equipped storage location: depot with concrete decay, holes and leaks in the roof (raining inside), no electricity, no heating;
- high relative humidity levels in the depot (with an average of around 72%, fig. 4) during at least the whole winter period, because of snow and rain inside;
- low temperatures in the depot (with an average of around 10°C, fig. 4) during the same winter period in the absence of a functional heating system;
- no regular visual inspections by the staff because the entire building had been declared unsafe by the fire brigade;
- no light inside the carriages owing to the turning off of the electricity in the depot;
- out of fear of theft and vandalism, extreme locking/sealing of the carriage doors and windows: no air circulation, no ventilation, no regular visual inspections;
- many microclimates with high RH-levels (above 85%) inside the carriages in difficult-to-access locations (mattresses, carpets, toilets, kitchen furniture...);
- old “dirt” (like grease stains) and severe dust deposition acting as a substrate for mould.

The exponential mould growth had to be stopped immediately. In 2013, KIK-IRPA started an initial emergency intervention in which air circulation was created inside the trains. The compartment doors and the small swing windows were opened. Alongside providing ventilation, the relative humidity (RH) in the carriages also had to be lowered to below 60%, a critical limit for mould growth.

Dehumidification with strict climate control was done in collaboration with the external firm BEPA (via public tender). Given the long-term exposure of the interior elements to a humid climate (around 72% RH), the dehumidification had to be set up with caution. The RH had to be lowered by no more than of 3% per 24 hours, to allow the climate-sensitive materials and objects in the coaches the time to adjust. The RH was gradually decreased from 73.5% to 53% over a span of 30 days. 53% RH was decided as the setting point and this average value was chosen since this would reduce the risk of mechanical damage to the most vulnerable textile materials, veneer, modern materials, etc... First, the dehumidifiers were set up to lower the RH value by 3% every four days. From 60% onwards, the RH fell by 1.5% every four days. On reaching the target value of 53% RH, ventilation and a constant air flow maintained the 53% level.

During the dehumidification, KIK-IRPA also verified the mould activity by taking mould samples at different moments. Although positive mould activity was always found, each time there was lower germination of the mould spores. At the start, germination was found even after two days but after 10 months of dehumidification, germination was only found after every three to four days. The cautious conclusion is that the dry atmosphere had its effect on the mould activity.\[12\]

Since the very start of the project, the climate in the depot and in all train carriages was continuously monitored, analysed and interpreted. The results of mould samples and air analyses were plotted. The air analysis showed that the mould growth had taken major proportions. The concentration of mould spores in the air (number of viable units per cubic metre or UFV/m³) was far above normal values. Where 800 UFV/m³ is the standard, a value of 1,500 UFV/m³ was found in some compartments. Individual personal protection was extremely important, so disposable half face respirators with the finest filter quality (FFP3), nitrile hand gloves and cleanroom coveralls with hood and Tyvek® boot covers were used.\[13\]
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Modern materials such as linoleum, plastic, Bakelite and rubber were dry cleaned or cleaned with demineralized water. Hard materials such as metal, glass and ceramic materials were disinfected with alcohol. Difficult to reach places such as behind ventilation grilles and heating elements were disinfected using an alcohol mist. The practical work in the carriages lasted six months, of which one month of preparatory work and one carriage every two to three weeks.

Towards the end of the project, KIK-IRPA prepared an extensive advisory report in which we described the general collection requirements. We drew up a list of collection requirements, based on the most significant risks and hazards. Everything was defined: at the level of the location, the building, the storage space, the carriages themselves, and the conservation policy. With the ten agents in the backs of our minds, we succeeded in defining general collection requirements, and action points for the long-term preservation of the carriages. Climate, ventilation, contamination, light, maintenance, inspection and safety were covered. A maintenance and inspection plan was also delivered. A better future preservation of the carriages primarily relies on the employees of Train World. Through regular inspections, calamities and damage to materials can be prevented. Special attention is also be given to a future Integrated Pest Management plan.

KIK-IRPA made detailed condition reports for each carriage and compartment. These reports showed the degree and the location of the mould attack and provided a clear picture of the degree of contamination.

In situ tests of cleaning products and methods were also made with a team of ten conservator-restorers, each specializing in their own knowledge domain (glass, textile, wood, metal, painting, modern and ceramic materials). These experts pointed out how persistent the mould was and how it could be removed.

The firm Helicon Conservation Support Ltd., specialized in preventive conservation and calamities, was allocated the contract to mechanically remove the mould in all the carriages. The same method was systematically used for the six carriages: from top to bottom (from the ceiling to the floor), compartment by compartment and especially in the direction of the ventilation flow of the dehumidifiers. Helicon staff worked wearing full protection, equipped with a museum vacuum cleaner with HEPA filter, a small bristle brush and a microfibre cloth. They cleaned the same surface several times and in various directions.

14 Kaat Sneiders, Fanny Van Cleven, Dahlia Mees, Caroline Meert, Chantal Fontaine, Jean-Albert Glatigny, Anne-Sophie Augustyniak, Greet Kockelkoren, Alessandra Girardi and Elke Otten.

[Fig. 4]
The first climate measurements in the depot between 12/04/2013 and 24/05/2013. Working document.
Pests: How to manage them in the context of KIK-IRPA’s workflow?

In the preventive conservation field, the term “pest” groups all living organisms that represent a danger for the tangible cultural heritage. They can alter the appearance or the structure of an artwork or a building, damaging it and destroying it, mostly by eating (or digesting in the case of mould) the constituent materials, or by using them for their nests. Microorganisms, insects and rodents represent the majority of pests affecting cultural heritage. For mitigating the risks of pest-inflicted damage, the heritage sector developed in the 1980s a comprehensive approach called “Integrated Pest Management” (IPM). This regroups all strategies to prevent, block, detect and treat the risks of infestation and infection.

IPM is a science-based decision-making process which provides a model for helping the user to choose the optimal solution (appropriate, cost-effective) for a particular pest situation. While pest control has always been undertaken individually by all colleagues, the KIK-IRPA Preventive Conservation Unit aims to design and implement a comprehensive IPM-plan, adapted to the institute’s specificities. A two-year pilot phase was launched in 2018, during which concrete measures were implemented. This action plan builds on the survey work undertaken three years earlier by two KIK-IRPA colleagues.

The results of the survey were used to define the specificities of the institute. Two kind of collections were identified: those that are owned and stored within the institute (archives, negatives, historical furniture) and the others coming from private or public collections that enter the building for specific study and/or restoration. This second case raised specific issues: where information provided by the owners concerning

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15 Strang and Kigawa 2018, s.p.
the object conservation conditions is insufficient to decide whether or not the objects should be allowed to enter the KIK-IRPA building or where their current state represents too great a risk (for example if actively infested). Furthermore, the fact that KIK-IRPA proposes multiple services means that, in the process of documenting, analysing and treatment, artworks generally transit via different work spaces within the institution and the risk of spreading an infestation, if not detected beforehand, is therefore significant.

A review of the available literature served as a basis for proposing a set of actions in table format, with a similar structure to that of the CCI Framework for Preserving Heritage Collections. This summary table both gave an overview of what needs to be done, and served as an effective tool for communicating with management [fig. 5]. The two specific features (owned collections and in-transit artworks) identified above and the survey work done by our colleagues helped us to identify in this table the major priorities for our IPM plan: the monitoring of the building and the creation of in and out procedures, while raising awareness among the staff and offering training. While the prevention logic would have required us to begin with the improvement of the building envelope—a hermetically sealed building is essential to prevent pests from accessing the collections—, the protected building status of the KIK-IRPA facility considerably reduced our room for manoeuvre. All works on the building itself fall under the responsibility of the Federal State Property Manager (Régie des Bâtiments) and should be ideally included in a master plan. Finally, we concluded that the initial steps as planned will help us to better identify the areas of weaknesses (in particular, the monitoring) and to report on those later.

By setting traps and monitoring the trapped insects and rodents, we get a better picture of the pest population already present within the building. The whole staff plays an important role in this monitoring work: whenever they detect an insect or an animal in the building, they hand it over or report it to the Preventive Conservation Unit to design and provide internal training for the whole staff. Internal communication plays also a crucial role in reminding people of the specific IPM actions and procedures, without which an IPM plan cannot work efficiently.

Light, UV and IR: Past and future lighting for the Mechelen Enclosed Gardens

Lighting conditions for heritage objects is a painful dilemma: light is a prerequisite for admiring works of art, but at the same time causes cumulative and irreversible damage. Light is a form of radiation. Three types of radiation are usually distinguished based on their wavelength: visible light (380-740 nm), ultraviolet radiation (UV, 10-400 nm) and infrared radiation (IR, 700 nm-1 mm). In principle, only visible light is needed to observe objects, but depending on the source, UV and IR radiation can co-occur. UV radiation has the highest energy and therefore the highest potential to induce chemical degradation reactions. IR radiation has lower energy and results in the heating-up of surfaces. Examples of damage phenomena related to irradiation are discoloration and fading of pigments and dyes, and the weakening and yellowing of textile and paper fibres.

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19 Framework for Preserving Heritage Collections 2015, s.p.
22 Blyth 2013, p. 243.
Degradation phenomena related to light were clearly observed in the seven Enclosed Gardens of Mechelen (Hof van Busleyden, Mechelen, Belgium) [fig. 6]. These are medieval wooden devotional cabinets with painted cabinet doors, decorated with polychrome wooden statues, silk flowers, vellum quilling strips wrapped in textile, relics, wax medallions etc. During the restoration treatment, one of the Enclosed Gardens was fully dismantled, permitting access to the front and reverse sides of the small fragments. The front sides of the textile fragments (silk and linen) were highly faded and extremely fragile after centuries of exposure to light. The reverse sides displayed bright colours that reflected the original chromatic splendour of the Enclosed Gardens [fig. 7]. In order to arrive at proper preventive conservation recommendations, future fading was simulated for different light exposure scenarios. Such simulations required information on the type of colorant and the past exposure.

Dye analysis was performed on small samples of the historical textile fragments, using High-Performance Liquid Chromatography with Diode Array Detector. The blue dye was identified as indigo (Indigofera or Polygonum sp.) or dyer’s woad (Isatis tinctoria L.), while the green dye was a mixture of

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indigo or woad and yellow weed (Reseda luteola L.). Other dyes present were the red dyes Caesalpinia sp. and dyer’s madder (Rubia tinctorum L.).

Past light exposure was estimated based on colorimetric measurements on the front and reverse sides of 11 fragments: blue coloured grapes and green coloured wine leaves. The measurements were performed with a portable colorimeter with a 4 mm aperture, a spectral range of 400-700 nm and a 20 nm resolution (BYK Gardner Colour-Guide 45/0 - 6807, Geretsried, Germany). A standardized light source was selected that simulates natural daylight in Northern and Western Europe (D65). A 10° standard observer modus was selected. To take into account possible gloss difference due to fibre direction, two different orientations were used for each measuring point: parallel and perpendicular to the fibre direction. At least 4 different measurements were performed on each fragment. Colour values were registered as \( L^* \), \( a^* \) and \( b^* \) (CIELAB-system), from which the colour change \( \Delta E_{76}^* \) is calculated as:

For the blue fragments, the average \( \Delta E_{76}^* \) value is 15.0 ± 4.0, for the green fragments, an average \( \Delta E_{76}^* \) value of 13.7 ± 2.5 was obtained. These \( \Delta E_{76}^* \) values give a valuable indication as to the colorant degradation, though one should keep in mind that: (1) the fading of colorants is dependent on different factors. Apart from the intensity and the irradiation spectrum, the discoloration also depends on the colorant concentrations, the use of mordants etc.; (2) the analysed fragments were measured after mechanical dry
cleaning. Despite this, remaining dust on the textile fibre can influence the result; (3) the textile fibres themselves could be discoloured due to ageing.

The results of the colorimetric measurements were subsequently plotted on graphs that relate the fading ($\Delta E^*$-values) to exposure (lux hours), based on the ISO blue wool standards (fig. 8)). Since both the blue and green colours were probably obtained with indigo, a light-fastness corresponding to ISO 5 was assumed (ISO rating system for light-fastness). This corresponds to a medium responsivity to light. Based on this, a historical light exposure of 83 and 76 mega lux hours (Mlxh) was estimated for the blue and green colours, respectively, with the assumption of UV-radiation in the past.

On the basis of these graphs, one can estimate future discoloration for different scenarios. For the Enclosed Gardens, six different situations were considered, differing in illuminance, exposure, and with or without permission to take photos with flash (fig. 9). For each scenario, a time horizon of 100 years was considered. Simulations were done for light sources with and without a UV-fraction. The future light dose for each scenario is calculated by multiplying the illuminance by the exposure. Notably, owing to the reciprocity principle, this results in the same light dose for scenarios 2 and 3. We simulated the future colour loss for a historic light exposure of 76 Mlxh. A simulation starting from a historic light exposure of 83 Mlxh has a similar result, with a slightly more limited future colour loss. For the calculation of the future colour loss, we assumed that all ISO classes are present equally in the Enclosed Gardens.

Figure 10 shows the future colour loss as a percentage of the original colour, and as a percentage of the remaining colour for the 6 scenarios of Figure 9. The higher energy related to a UV-containing light source clearly causes a faster colour change. This is particularly visible in the colour change relative to the original colour. Figure 11 demonstrates whether the percentages of future colour loss effectuate a visual colour change. This figure shows the change in $\Delta E^*$ for each ISO class, and for three different scenarios (exposure to 6.26, 12.52 and 50.08 Mlxh). A distinction is also made here between illumination with and without UV.

Colorants in ISO classes 1 and 2 are, owing to historical exposure, almost fully faded. Therefore, their future colour loss is negligible. Colorants within class 3, 4 and 5 will suffer the highest colour change. However, without UV-fraction in the light source, the colour change is below the “just noticeable colour change” of $\Delta E^* = 1.5$ for a light dose of 6.26 and 12.52 Mlxh. With the higher light dose of 50.08 Mlxh, this threshold is exceeded for classes 3-5. In the presence of UV-radiation, the threshold of $\Delta E^* = 1.5$ is already exceeded for ISO-class 4 with a limited light dose of 6.26 Mlxh. However, this “just noticeable colour change” can only be observed by trained observers. Moreover, it is a colour change over a time horizon of 100 years, and the faded material is not directly placed next to the initial colour. Therefore, this threshold is rather strict and a higher $\Delta E^*$-value of 3.5 can be considered as a significant colour change. Without UV-radiation present, this value is only exceeded for ISO-classes 4 with a light dose of 50.08 Mlxh. It can be concluded that future colour loss is limited when the objects will be illuminated at low intensity, and UV-radiation is avoided.

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24 Control of damage to museum objects by optical radiation 2004.
25 Michalski 2014, s. p.
27 Mokrzycki and Tatol 2012, p. 15.
This simulation only considers colour change due to the degradation of the colorants. Radiation can, however, also enhance the degradation of the textile carrier. Of all natural fibres, silk is the most light-sensitive, certainly in the presence of UV-radiation. This is related to the presence of the amino-acids tryptophan, tyrosine and phenylalanine that absorb UV-radiation (220-370 nm) and subsequently oxidize to form chromophore groups that give the silk a yellowish colour. In addition, photodegradation also decreases the degree of polymerization and reduces cross-linking. This results in weak and brittle silk.

Translating the results of this extensive study to daily museum practice, the Court of Busleyden museum was recommended to keep future light levels for the Enclosed Gardens as low as possible and the illumination limited in time. For the most light-sensitive materials – silk, parchment and paper –, a maximum of 50 lux was to be established, avoiding all UV-radiance, with a maximum exposure of 10 µW/lm. Introducing a lighting plan can be an option to illuminate different objects during a restricted time, taking care not to induce uneven light damage on the objects. Working with sensors, limiting illumination time to the visitor’s presence can be achieved but is a more costly alternative. When implementing these recommendations, the public’s experience certainly needs to be taken into account. It was advised to lower light levels in adjacent areas to let the visitor’s eyes get accustomed to the dark. In the permanent exhibition setup, the very low light level requirements are met and a special reduced lighting accustomization zone has been installed before entering the exhibition room. In this way the museum allows the public to enjoy the unique Enclosed Gardens while protecting them as much as possible from further light damage.
Physical forces: Music makes you vibrate... but also your building and your collection

Five types of forces can cause mechanical damage to art objects: impact, shock, vibrations, pressure and abrasion. Art objects can be exposed to these forces during handling, transport, exhibition and even storage. Impact and shock (e.g., an object falling on the ground) usually occur in very short time periods and result in direct consequences. The consequences of the other physical forces are often less visible due to their cumulative effects. For this reason the impact depends not only on their intensity level but also on their frequency. Physical forces are sorted depending on their incidence and their intensity, enabling them to be listed in four sub-categories: catastrophic forces (low incidence, high intensity); working forces (high incidence, moderate-to-high intensity); cumulative forces (high incidence, low intensity) and low-level forces (variable incidence, low intensity).

Museums and other cultural heritage institutes are confronted with increasing numbers of situations producing physical forces, in particular vibration. This type of physical force can be damaging for objects but also for architectural structures. The Brussel City Museum provides a good example. As this museum is located in the Grand-Place, the central and historic square of Brussels, many events take place within or near to it: daily movement of people in the museum, variable traffic in the surrounding streets and, above all, noisy and festive gatherings such as concerts or cultural events: window panes trembling in the glazing bars of the frames and resonance on the stained-glass windows at the back of the facade.

The Brussels City Museum conserves the tapestry cartoon of Pieter Coecke van Aelst, an exceptional piece from the 16th century (1535) (fig. 12)). Throughout the conservation treatment of the cartoon (2016-2017), the KIK-IRPA Preventive Conservation Unit accompanied the Museum and the conservation team with research to design a new display for this major piece in optimal environmental conditions. KIK-IRPA began this study with a basic risk-analysis based on the 10 agents of deterioration, in order to identify the major risks for the collection and more specifically for the cartoon itself. After that, a more in-depth analysis of environmental conditions in three potential places helped to choose the most “risk-free” future exhibition space and to analyse it.

Given the Museum’s location in a busy neighbourhood, this analysis included the problem of vibration. At the request of KIK-IRPA, under the supervision of Bill Wei (Rijksdienst voor het Cultureel Erfgoed, Amersfoort), the firm Tractebel evaluated, using the DIN 4150 standard (Parts II and III), the potential hazardous effects of acoustic vibrations on the collection, by measuring them with an accelerometer combined with amplifiers and connected to sensors placed in two separate locations of the permanent exhibition room. The DIN 4150 standard allows specialists to determine whether or not the – essentially sound – vibrations to which an environment is subjected are or are not problematic in the construction sector. However, current research has not yet established clear guidelines on the effects of vibration on works of art. Generally, the recommended precautionary reference point concerns public nuisance in its low values and a risk of damage to objects and structures such as historic buildings in its high values (2 mm/sec).

The measurements were made on the window and on the floor, to give an idea of the vibration levels on the walls and also of the effect of the acoustic excitation of the artworks through the windows. Three sensors (X, Y and Z) on the floor and one sensor on the window [fig. 13] were used to register every frequency from 1 or 2 to 100 Hz continuously during 24h, taking into account all the vibration intensity levels. The measurements of the intensity level of vibrations on the windows (Ommegang, music festivals, jazz and rock concerts). The museum staff noticed vibration impact during these events: window panes trembling in the glazing bars of the frames and resonance on the stained-glass windows at the back of the facade.

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[Fig. 12]

29 Wei, Saugue and Wink 2014, s.p; Marcon 2018, s.p.
30 Marcon 2018, s.p.
Ten Agents of Deterioration as a framework for KIK-IRPA’s preventive conservation projects

[Fig. 13]
Location of sensors X, Y, Z on the window (a) and on the floor (b), Brussels City Museum, 1st floor, 24-09-2016.

[Fig. 14]
Graphs of the intensity levels of the vibrations on the window (a) and on the floor (b, c, d) during sound checks and outside music performances. Working document.
and floor of the first floor of the museum were translated into graphs [fig. 14].

The vibration levels measured on the floor increased in all three measuring directions during sound checks and performances, but not to the extent that they can be considered annoying to people or harmful to buildings according to DIN 4150 part II and III [fig. 15]. In the x and y measuring direction, the third band (31.5, 40 and 100 Hz) was most strongly excited. For the z measurement direction this is the 31.5, 40 and 200 Hz third band. These measures, which reflected both the impact of visitor movements in the building and the effects of a concert on the Grand Place, opposite the museum, were compared with the measures recommended by the standards mentioned above. The vibration measurements on the floor were performed close to the side wall. In the vertical direction, it is likely that vibration levels are significantly higher in the middle of the floor. The windows “shook” during the performances and sound checks. The highest measured vibration speed value at the 35 Hz resonance frequency of the window was 80 mm/s (peak particle velocity measured during the sound checks). Vibrations in this order of magnitude can, in combination with material impurities, thermal residual stresses or notching, result in damage.

The results show that the recorded acoustic vibrations meet the DIN 4150 standard and that they should not cause any risk for the hanging of the tapestry cartoon, even if the latter were to be suspended on one of the sidewalls of the museum. Elsewhere, however, the vibrations could lead to damage to non-homogeneous materials (e.g. glass with impurities), thermal stress, weaknesses and defects. Local damage such as cracks have already been noticed on the windows of the back facade and windows with glazing bars. Similarly, if fixtures such as temporary walls or exhibition furniture (like showcases or screens) were to be installed, they would clearly suffer the adverse effects of vibration. Therefore, it is recommended that the vibration levels measured on all the walls of the room remain lower than the prescribed values of the reference value (2 mm/s).

In summary, acoustic sources vibrations related to live music are not to be considered as distressing: handling, transit vibration, and the effects of other agents are more relevant concerns in the case of this Museum. With regard to the hanging of the tapestry cartoon on one of the side walls of the building, the vibration levels of the side walls of the building will always remain below 2 mm/s, however, it is recommended to check the resonance of the suspension mechanism in order to avoid vibration reinforcement between the side wall and the tapestry cartoon. Following the same line of reasoning, a backing board was put into the frame with the aim of reducing vibrations, buffering climate fluctuations and protecting the back from handling.
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However, such microclimates could also become a potential danger due to the building up of harmful gases in case of an inappropriate material choice for the showcase construction, or the presence of a work of art that off-gasses harmful compounds.

To check the protective effect of the showcase for external and internal pollution, several tests can be performed. Some of these are demonstrated on a showcase that was temporarily available at the KIK-IRPA in 2015-2016: dust (deposited dust and airborne particles), nitrogen dioxide (NO2), sulphur dioxide (SO2), acetic acid and formic acid. The air tightness of the showcase was determined with the CO2-method described by Calver et al.,\textsuperscript{35} with the result of 0.55 ± 0.07 air changes per day (acd\textsuperscript{-1}). The lower the number of air changes per day, the more airtight the showcase, and the better its buffering performance for outside pollution and dust ingress. For an efficient passive climate control, an air tightness of around 0.4 acd\textsuperscript{-1} or less is recommended.

The rate of dust deposition in and out the showcase was tested with the “loss of gloss” technique. Ten microscope slides were meticulously cleaned with microfibre cloth, and subsequently subjected to gloss measurements using a micro-TRI-gloss meter at an angle of 85° (BYK Gardner, Geretsried, Germany). Directly after this zero measurement, 5 slides were placed inside the showcase and 5 others were placed on top of the showcase. The test was repeated twice, in the period 07/07/2016 to 21/09/2016 (test 1) and in the period 21/09/2016 to 09/01/2017 (test 2). Directly after exposure, the gloss of the microscope glasses was remeasured. One percentage of gloss reduction is translated to one “soiling unit” (su). The results are represented in soiling units per week.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Instrument</th>
<th>Specifications</th>
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</thead>
<tbody>
<tr>
<td>PM</td>
<td>Lighthouse 3016-IAQ (Lighthouse, Fremont, CA, USA) (Instrument from the University of Antwerp, AXES research group)</td>
<td>Particle counter, simultaneous measurement of 6 particle fractions within the size range of 0.3-10 µm.</td>
</tr>
<tr>
<td>Gases</td>
<td>SainSmart MQ138 formaldehyde aldehyde gas detection sensor module, connected to an Arduino board (AIRCHECQ-project)</td>
<td>The sensor measures (non-specific) following VOCs:</td>
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<tr>
<td></td>
<td></td>
<td>* Formaldehyde (1-10 ppm)</td>
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<td>* Aceton (10-300 ppm)</td>
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<td>* Alcohol (30-300 ppm)</td>
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<td></td>
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<td>* Methanol (5-100 ppm)</td>
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<td></td>
<td></td>
<td>* Tolueen (10-100 ppm)</td>
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<tr>
<td>Light</td>
<td>Hanwell ML4000UV/LUX (IMC group, Letchworth, Hertfordshire, UK)</td>
<td>* 10 to 5000 lux in the wavelength range of 400-700 nm</td>
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<tr>
<td></td>
<td></td>
<td>* 20 to 2000 mW/m² in the wavelength range of 215-365 nm</td>
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[Fig. 17] Concentrations of NO2, SO2, formic acid and acetic acid, measured with Radiello diffusion tubes inside the showcase, and around the showcase (“room”). Working document.

Pollutants: Air-tight showcases can be harmful too…

Pollutants are considered as any substance that can cause adverse effects to heritage objects. Generally, these substances can reach the object in three different ways. (1) Pollutants can be transferred by direct contact. Examples are the cleaning residues from a restoration treatment, oil and salts from the skin when touching an object, pesticides, etc. (2) Pollutants can also be airborne, comprising both gaseous and particulate pollutants. The key airborne pollutants are identified as acetic acid, hydrogen sulphide, nitrogen dioxide, ozone, sulphur dioxide, fine particles and water vapour. (3) Finally, intrinsic pollutants originate in the object itself. Certain object compounds can be detrimental for other parts of the same object (e.g. brass beads on a leather belt\textsuperscript{33}). In addition, certain materials such as wood or cellulose acetate can emit themselves gases such as acetic acid, which can be dangerous for themselves and can also influence the degradation of other collection items. These are secondary intrinsic pollutants.\textsuperscript{34}

To protect artworks from their (polluted) environment and to create specific microclimates, showcases are often introduced. The determining factor for estimating showcase efficiency is the showcase air exchange rate.\textsuperscript{34} Showcases with high air exchange rates will not act as a good barrier for external influences such as climate, pollution, insects, etc. Low air exchange rates, on the other hand, have the potential to create microclimates.

However, such microclimates could also become a potential danger due to the building up of harmful gases in case of an inappropriate material choice for the showcase construction, or the presence of a work of art that off-gasses harmful compounds.

To check the protective effect of the showcase for external and internal pollution, several tests can be performed. Some of these are demonstrated on a showcase that was temporarily available at the KIK-IRPA in 2015-2016: dust (deposited dust and airborne particles), nitrogen dioxide (NO2), sulphur dioxide (SO2), acetic acid and formic acid. The air tightness of the showcase was determined with the CO2-method described by Calver et al.,\textsuperscript{35} with the result of 0.55 ± 0.07 air changes per day (acd\textsuperscript{-1}). The lower the number of air changes per day, the more airtight the showcase, and the better its buffering performance for outside pollution and dust ingress. For an efficient passive climate control, an air tightness of around 0.4 acd\textsuperscript{-1} or less is recommended.

The rate of dust deposition in and out the showcase was tested with the “loss of gloss” technique. Ten microscope slides were meticulously cleaned with microfibre cloth, and subsequently subjected to gloss measurements using a micro-TRI-gloss meter at an angle of 85° (BYK Gardner, Geretsried, Germany). Directly after this zero measurement, 5 slides were placed inside the showcase and 5 others were placed on top of the showcase. The test was repeated twice, in the period 07/07/2016 to 21/09/2016 (test 1) and in the period 21/09/2016 to 09/01/2017 (test 2). Directly after exposure, the gloss of the microscope glasses was remeasured. One percentage of gloss reduction is translated to one “soiling unit” (su). The results are represented in soiling units per week.

\textsuperscript{32} Werner et al 2012, p. 3-20.
\textsuperscript{33} Tétreault 2018, s. p.
\textsuperscript{34} Thickett, David and Luxford 2015, p. 19-34.
\textsuperscript{35} Calver et al 2005, p. 602.
WIVINE ROLAND-GOSSELIN, WILLEMIEN ANAF, LAURA DEBRY, ELKE OTTEN, ESTELLE DE BRUYN, MARJOLIJN DEBULPAEP, HILKE ARUS AND GERTJAN MADALIJNS

Concentrations of formic and acetic acid. These organic gases are often linked to internal sources, such as emissions of (inappropriate) construction materials. In this way, with a single type of diffusion tube, one can estimate both the buffering effect of the showcase for external gases and the building-up of harmful gases inside the showcase. On top of (“room”) as well as inside the showcase, a set of three diffusion tubes were placed for a period of 2 weeks (09/01/2017 - 23/01/2017). Directly after sampling, the diffusion tubes were analysed by the University of Antwerp.

From the results, it is clear that the showcase is an effective buffer for dust deposition [fig. 16]. For test 1, the inside/outside ratio of the showcase is 0.08. For test 2, this ratio is 0.12.

Radiello diffusion tubes (cartridge code 166, Fondazione Salvatore Maugeri, Padova, Italy) were used to determine the concentrations of NO₂ and SO₂ inside and outside the showcase. These oxidizing gases usually have outdoor sources (traffic, industry, …). The same diffusion tubes also make it possible to define the concentrations of formic and acetic acid. These organic gases are often linked to internal sources, such as emissions of (inappropriate) construction materials. In this way, with a single type of diffusion tube, one can estimate both the buffering effect of the showcase for external gases and the building-up of harmful gases inside the showcase. On top of (“room”) as well as inside the showcase, a set of three diffusion tubes were placed for a period of 2 weeks (09/01/2017 - 23/01/2017). Directly after sampling, the diffusion tubes were analysed by the University of Antwerp.

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* Acetone (10-300 ppm)
* Alcohol (30-300 ppm)
* Methanol (5-100 ppm)
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volatile organic gases (VOCs) in real-time. Figures 18-19 give an overview of the instrumentation used.

Figure 20 provides an overview of the results of this experiment, performed on 12/07/2017. Around 8:55 am all devices were installed on top of the showcase. Around 10:15 am everything was placed inside the showcase, after which the measuring devices were placed back on top of the showcase at 3.40 pm to continue measuring for another 40 minutes. For all parameters, a clear shock can be seen when the setup was placed inside and subsequently outside of the showcase. The showcase, constructed from anti-reflective glass with 2 layers of polyvinyl butyral (PVB), mainly blocks the UV fraction of the light, for about 93%, calculated on the absolute UV values (mW lm$^{-1}$). It also limits the illuminance (lux) by approximately 24%. These are both target percentages because data was not simultaneously collected in- and outside the showcase.

For fine dust, the showcase needs a limited period of time to reach a stable state after opening and closing it to place the measuring devices inside. To get an indication of the percentage of particulate matter that is retained per fraction, calculations were performed with the data from the first period outside the showcase (75 minutes), and data from the last 75 minutes in the showcase. The showcase holds back 100% of the particles larger than 2.5 µm. Furthermore, 99.97% of the PM$_{2.5}$ fraction (particles with a diameter of 1 to 2.5 µm), and 99.81% of the finest PM$_{1}$ fraction (particles with a diameter < 1 µm) are retained.

The gas sensor, finally, gives a significant increase in signal. This confirms the measurements of the diffusion tubes that an internal source of organic gases is effectively present. This particular display case is therefore not suitable for displaying art objects that are sensitive to organic gases.

(Department of Chemistry, AXES-research group). Analysis was performed with ion chromatography (Metrohm, Antwerp), following the methods as described by Radiello (www.radiello.com) and Kontozova-Deutsch et al.. Figure 17 shows the concentrations of the different gases in and around the showcase. As expected from the showcase’s air exchange rate, the concentration of NO$_2$ is significantly lower inside the showcase compared to its surroundings, with an indoor/outdoor ratio of 0.06. SO$_2$ is hardly measurable, even not after a long sampling time of 2 weeks. These low concentrations are thanks to the strict European policy for SO$_2$ emissions in recent decades. For the organic acids, the concentrations inside the showcase are significantly higher. This indicates an internal source, probably the coated MDF used for the showcase construction. The coating does not completely shield the MDF everywhere.

Finally, in collaboration with the AIRCHECQ-project from 2014 to 2018 (University of Antwerp, BELSPO-Brain BR/132/A6/AIRCHECQ), an elaborate setup was tested to measure airborne dust (particulate matter, PM), light (illuminance and UV-radiation), and

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39 Tidblad 2013, p. 40.
To minimize the risk of water damage and its consequences for a collection, an action plan must focus first on the location of this collection, at the level of the building (envelope), the room, the equipment and the objects themselves [fig. 21]. To elaborate an action plan against water damage, one cannot ignore the storage rooms. As a matter of fact, approximately 90% of our cultural heritage is not on display but conserved in storage, out of sight of the public.

Stored objects get less attention and fewer resources are allocated to them. Moreover, most of the infrastructure used for storage is not designed nor suitable for the conservation of a collection. These storage spaces are usually situated in less appropriate parts of the building such as attics or basements.

In order to map the current condition of conservation conditions worldwide, ICCROM and UNESCO launched an International Storage Survey in 2011. The results of 1490 respondents clearly demonstrated the critical situation. As a consequence of the inadequate storage conditions that were reported, about 60% of the objects in these storage areas are considered to be in danger.

The respondents face important issues that prevent them from ensuring the long-term conservation of their collections. The survey revealed that 20% of the museums had already suffered damage due to water, fire or natural disasters. In case of a calamity, additional risks of damage arise when objects are on the storage floor or when there is insufficient space for circulation, which is the case for 25% of the museums. In half of the

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40 Maes, Veerle and Olbrechts 2015, p. 36.
41 Directive 2007/60/EC 2007, p. 298/27; De Voorlopige OverstromingsRisico-Beoordeling in Vlaanderen 2018, p. 24; Évaluation préliminaire des risques d’inondation 2018, p. 31; L’Évaluation préliminaire des risques d’inondation pour la région de Bruxelles-Capitale 2018, p. 20. These three reports estimate that, in Flanders, with the exception of 8 municipalities, all municipalities have a significant, high or very high flood risk by pluvial or fluvial flood. In Wallonia, 115 classified buildings were marked by flood events between 1994 and 2018. In Brussels, the whole region is considered as an area with a high potential of flood risk: floods will occur in the future and affect cultural heritage.

45 Objects in museum storage in more danger than you think 2016, s. p.
museums, there is too little space for the collection and a lack of storage units.

This survey expressed the necessity of undertaking action, in particular considering the precarious position of small museums in need of solutions but lacking necessary resources. As many of the Belgian museums find themselves in this situation, the Preventive Conservation Unit of KIK-IRPA launched a national strategy: RE-ORG Belgium. This strategy is embedded in the joint international initiative of ICCROM, CCI and UNESCO which developed and diffused the RE-ORG method. This method enables museum professionals to examine which adaptations could be made to the building, the furniture, the management and the collection with the means in situ, to improve storage conditions and meet fixed quality criteria. It incorporates the following crucial parameters: it is internationally applicable, within reach of the large heritage community, it is feasible with a minimum of resources and it should altogether be a guarantee for success.

Characteristic for the RE-ORG method is that it guides users in systematically dealing with the situation. Each action to be undertaken is methodically elaborated in each of the four phases of the step-by-step method, incorporating the latest knowledge in the field of preventive conservation and collection management. Throughout the working process, risks are mapped, the documentation system is evaluated, the collection management is investigated and the cost-effectiveness of a solution is calculated before implementing it.

Every institution gains insight by collecting all essential data, but also by quantifying them by means of one of the 15 worksheets. Number of square metres of the floor in use, number of objects divided into 12 different categories, percentage of fullness of furniture, etc.; each of the significant elements at stake are registered to calculate mitigation actions and plan improvement processes. The situation is visually documented as well and literally mapped in different functional plans. As a result, each museum works out a solution adapted to its given situation. This solution is as a consequence achievable with the given space and budget.

At a single glance, one can see that, following storage reorganization, storage conditions have improved after a RE-ORG campaign, and the same can be concluded by the self-evaluation form. But also in the use of the collection and the storage itself, the effects of RE-ORG can be felt in practice. It is not uncommon for objects thought to have been lost to reappear, as by reorganizing the risk of dissociation is also diminished.

When looking at the “sudden agents”, the risk of loss of value to the collection in case of a calamity, is reduced as well. Attempts at theft remain less unnoticed in a well-organized storage room and stand less chance when the secure access to the storage is verified and updated. Free circulation through liberated pathways means a crucial gain in time at an intervention in case of a calamity. One of the 21 museums that participated at the RE-ORG Belgium campaign, experienced this during a substantial water damage crisis: at a first incident before reorganizing their storage, 200 artworks were evacuated amongst which 70 were damaged and some totally lost. The extent of an unfortunate second incident after the reorganization project was limited to only three affected objects and none of the objects were lost this time, as there were no more objects on the floor and every object was stored in suitable furniture [fig. 22].

In Belgium, the RE-ORG strategy already counts three national campaigns or editions coordinated by the KIK-IRPA Preventive Conservation Unit, in which
in the greatest detail. Today, it proves that established taste and well-chosen creativity can stand the ravages of time. The building was conceived by modernist architect Charles Rimanque, while the interior was designed by the leading designers and companies of post-war Belgium. Interior designer Stéphane Jasinski and his Atelier, renowned for their stylish and high standard contemporary interiors, created a design implementing a progressive vision on the American inspired so-called Corporate Design culture. The Ateliers Jasinski were responsible for the institute’s public spaces, and especially the boardroom and director’s office [fig. 23]. The iconic furniture manufacturer Kortrijkse Kunstwerkstede Gebroers De Coene completed the interior. Although the interior looks integrally preserved, over the years dissociation was fed by budget cuts, lack of interest caused by an outdated view on the Corporate Design period, obvious traces of daily wear and the institute’s personnel simply not being aware of the collection’s importance as an architectural ensemble. Until the early 1980s, the furniture was maintained annually with special treatments for different leathers, lacquers and woods. Because of the aforementioned reasons this specific care ceased. Objects and furniture got moved around, worn down or disappeared [fig. 24].

An awareness today of the significance of the KIK-IRPA’s interior and its acknowledged value as a historic ensemble has led to a change in perspectives. Since 2007, the building and a part of the interior have a protected status. The KIK-IRPA’s interior is divided into several sub-collections such as, for instance, a collection of chairs, a collection considered as a total design for one specific room, or a collection of artworks still displayed as foreseen in the building. To maintain and to conserve this whole collection that is still in use, it was essential to set up a collection plan. Also applied by museums and other institutions possessing one or more collections of different kinds, such a plan is a suitable way to keep track of everything on site and to learn to understand the (un)importance of in-house objects. The challenge was to make an inventory of and valorise a collection that was designed for daily use but is now considered as a remarkable interior collection. This called for a specific approach, different from a museum context where the objects are not anymore used as daily objects.

The collection plan consisted of an inventory, including a full and detailed description of all the original objects and furniture, enriched with historical documentation. In collaboration with KIK-IRPA photographers, high quality photographs were taken to help documenting, describing and assessing their condition in 2017. After gathering all these data, condition reports were prepared for a number of chairs chosen either for their very poor condition or for their uniqueness (only one or two examples left in the institute)
Ten Agents of Deterioration as a framework for KIK-IRPA’s preventive conservation projects

After almost 60 years of operation, the KIK-IRPA’s primary function as a dynamic scientific institute is still more or less the same. Documentation, laboratories and conservation-restoration remain the three principal tasks. This is the obvious reason why its building has kept its original state. It has not become an empty, soulless box like dime-a-dozen office buildings in the capital and has not risked demolition. The collection plan is aimed to safeguard its historic interior ensemble for its future users and to tackle the threats and severe consequences that dissociation may cause.

Regarding the history facts and with the achievements of the collection plan, the institute is now aware of its unique position in Brussels architectural landscape and of its valuable interior.

[fig. 25]. These conditions were subdivided into “fit for use”, “to be exhibited” or “to be stored”. The creation of a storage room ensured the preservation of the “to be stored” category. Protective covers in washed bale cotton were created in collaboration with the textile conservation studio, providing them a first layer of protection against potential damage agents such as dust. Acid-free information labels were attached to the objects to facilitate their identification. Since then, the chairs have been stored on metallic shelves in a storage room near the preventive conservation offices. Besides this, some objects, such as the original model of the KIK-IRPA building which was formerly displayed in the management office, received a light conservation treatment by a specialized restorer. The director’s office and adjacent boardroom were, based on original architectural plans, brought back to their foreseen set up, taking contemporary ergonomic requirements into account. As part of this enhancement process, a small exhibition of original furniture and photos was made for KIK-IRPA open days. The project was completed with the development of a protocol for the future use of the original furniture, explaining how to valorise the collection and how to sensitize users and KIK-IRPA staff. Combined with the value assessment of the interior, this collection plan determined priorities for future decisions impacting the preservation of the original design.

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<table>
<thead>
<tr>
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<th>Participant</th>
<th>CURRENT STATE</th>
<th>USE</th>
<th>INTERVENTION</th>
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General advices: 60% 50% 60% 100%

Discussion and conclusion

In the foregoing, among the projects of the KIK-IRPA Preventive Conservation Unit, one substantial example was selected for each of the ten agents of deterioration. This presentation offers better insights into the framework and illustrates its practical applications. However, it is artificial to select only one agent for each project: usually, multiple risks are at stake. The Preventive Conservation Unit is frequently approached by the heritage field with questions regarding temperature, relative humidity and light. During an on-site visit, the preventive conservation specialist does not focus only on the original request: thanks to the framework of the ten agents, a broader look is taken at the situation, and further risks and hazards are noticed. This broader view can be considered as the first work phase of each project. In order to evaluate priorities and decide on mitigation measures, it must be combined with a risk management approach. It perfectly demonstrates applied preventive conservation, with an integrated vision at project level: theoretical background meets practice to arrive at a global approach. By recapitulating all the agents for each project, specific hazards for each situation are identified. Based on these hazards, the specialist deduces practical recommendations that the heritage caretaker can implement. Such recommendations could consist of actions to avoid or block a certain hazard, but could also encourage the introduction or improving of procedures (e.g., emergency plan, integrated pest management plan, etc.).

All in all, the framework of the Ten Agents of Deterioration leads to the describing of a wide spectrum of risks and hazards. Even so, in any particular project, strict adherence to the framework may potentially prove insufficient, notably because of the significant difference between sudden and slow agents and the importance of the human factor. Once the risks are identified, they must be analysed through a risk management approach in order to identify the preservation priorities in the project. This systematic procedure has been implemented in every project led by the Preventive Conservation Unit since its creation. The numerous and various activities engaging the Unit today prove the success and positive impact of this method.

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Résumé – Samenvatting – Abstract

FR:: La cellule de conservation préventive de l’IRPA utilise le cadre des Dix agents de détérioration afin d’identifier les défis de préservation des collections rencontrés par les institutions culturelles. Ce cadre évalue les risques que les agents individuels représentent pour une collection, et propose des solutions pratiques d’atténuation. Cet article présente plusieurs projets récents et d’envergure se penchant sur quelques agents de détérioration courants. Pour la collection de négatifs photographiques en nitrate de cellulose de l’IRPA, la cellule a réduit le risque de dégradation chimique dû à une température de stockage inappropriée. Elle a fourni un rapport consultatif détaillé au Musée du Train (Train World) pour six wagons historiques souffrant de moisissure en raison d’une humidité relative inadaptée. Pour l’IRPA, elle a conçu et mis en œuvre un plan de lutte intégrée contre les agents de détérioration afin de réduire le risque de dommages causés par eux. Elle a analysé différents scénarios d’exposition à la lumière et évalué les impacts des différents éclairages sur les jardins clos préservés à Malines. Elle a mesuré les risques dus aux vibrations de la collection du Musée de la Ville de Bruxelles, situé sur la Grand-Place, un lieu particulièrement bruyant. Elle a réalisé une série de tests pour vérifier l’étanchéité d’une vitrine à la poussière et à d’autres agents polluants. La cellule a également lancé la stratégie nationale RE-ORG Belgium pour aider les petits musées et ceux de taille moyenne à réorganiser leurs dépôts et réserves, de manière à réduire considérablement les risques soudains tels que les incendies, les dégâts d’eau ou les vols. Enfin, elle a mis en évidence le processus de dissociation affectant le mobilier d’origine dans le bâtiment de l’IRPA.

Mots-clés : conservation préventive; agents de détérioration; risques; dommages; température; lumière; humidité relative; agents polluants; vibrations; dissociation.

NL:: De Cell voor Preventieve Conservatie van het KIK maakt gebruik van de Tien Schadefactoren om de uitdagingen op het gebied van de conservatie van collecties waarmee culturele instellingen worden geconfronteerd in kaart te brengen. Hij beoordeelt de risico’s van individuele factoren voor een collectie en biedt praktische oplossingen om die risico’s te beperken. Deze paper presenteert recente en grootchalige projecten, door de bril van de factor(en) die de kern van het probleem vormden. Voor de collectie fotonegatieven van cellulosenitraat van het KIK verminderde de Cell het risico op chemische degradatie als gevolg van een onjuiste opslagtemperatuur. Hij bood uitgebreid advies aan het Train World-museum voor zes historische treinstellen die als gevolg van een ongeschikte relatieve vochtigheid aan schimmelvorming waren blootgesteld. Hij ontwierp en implementeerde een Geïntegreerd Ongediertebestrijdingsplan voor het KIK om het risico op schade door ongedierte te verminderen. Hij stimuleerde verschillende lichtbloeitestingsscenario’s om de impact te onderzoeken van verlichtingskeuzes op de Besloten Hofjes die worden bewaard in Mechelen. Hij mat trillingsrisico’s voor de collectie van het Museum van de Stad Brussel, gelegen op de drukke Grote Markt van de hoofdstad, en voerde een reeks testen uit om de luchtdichtheid van een vitrine te controleren en de inhoud ervan te beschermen tegen stof en verschillende andere vervuilende stoffen. Hij lanceerde ook de nationale strategie van RE-ORG Belgium om kleine en middelgrote musea te helpen om opslag zo te reorganiseren dat plotse risico’s zoals brand, waterschade en diefstal worden verminderd. Ten slotte heeft de Cell het dissociatieproces voor het voetlicht gebracht dat het originele meubilair in het gebouw van het KIK bevloedt.

Trefwoorden: preventieve conservatie; schadefactoren; risico’s; schaden; opslagtemperatuur; verlichting; relatieve vochtigheid; vervuilende stoffen; trilling; dissociatieproces.

EN:: KIK-IRPA's Preventive Conservation Unit uses the Ten Agents of Deterioration framework to identify collection preservation challenges encountered by cultural institutions. It evaluates the risks that individual agents represent for a collection and then provides hands-on mitigation solutions. This paper presents recent and large-scale projects, through the prism of the agent(s) that were at the heart of the problem. For the KIK-IRPA's cellulose nitrate photographic negatives collection, the Unit reduced the chemical degradation risk due to inappropriate storage temperature. It provided an extensive advisory report to the Train World museum for six historic train carriages subject to mould due to unsuitable relative humidity. It designed and implemented an Integrated Pest Management plan for KIK-IRPA to reduce the risk of pest damage. It stimulated different light exposure scenarios to investigate the impacts of lighting choices on the Enclosed Gardens preserved in Mechelen. It measured vibration risks for the collection of the City of Brussels Museum, located on the city's noisy Grand-Place. It carried out a series of tests to check the airtightness of a showcase against dust and several other pollutants. It also launched the RE-ORG Belgium national strategy to help small and medium-sized museums reorganize their storage, in a way that greatly reduces sudden risks such as fire, water damage or theft. Finally, the Unit has highlighted the dissociation process affecting the original furniture in the KIK-IRPA's building.

Keywords: preventive conservation; agents of deterioration; risks; damages; temperature; light; relative humidity; pollutants; vibration; dissociation process.