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REPORT

Innovative Tools for Exhibition Purposes: Environment and Damage Assessment
Malta Centre for Restoration
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Introduction

Most of the lectures on this six-day advanced training school were presented to practitioners by European scientists working on research projects, funded by the European Union, connected with improving damage prediction and assessment of cultural heritage. The inter-government projects discussed in detail were: LiDO (on light degradation), MIMIC (concerning the production of an early warning system to indicate levels of risk to objects and, particularly, paintings), IDAP (on the degradation of parchment), MASTER (on the degradation of organic objects), IMPACT (predicting indoor concentrations of externally generated pollutants) and MODHT (researching the degradation of historic tapestries). In addition to investigating degradation processes most are also focused on the production of an early warning system or sensor to help conservators take action before damage to the objects is visible.

The training school was funded through COST (European Cooperation in the field of Scientific and Technical Research) Action G8. As the title suggests; emphasis is on funding co-operation rather than research. Action G8 began in 2001 and is due to end in 2005-6; it has been established to facilitate co-operation and interaction across the European Union between the practitioners and researchers of cultural heritage (historians, archaeologists and conservators) and natural scientists (physicists, chemists and material scientists) (for further information see http://srs.dl.ac.uk/arch/cost-g8). There are six working groups in Action G8 and their aims are 'to achieve a better preservation and conservation of cultural heritage by increasing the knowledge of museum objects through non-destructive analysis and testing'. COST Action G8 facilitates a close collaboration and knowledge exchanges within each working group, which will result in the transfer of practical experience between different European countries. Some of the measures include:

- workshops, with an objective to engage a broader audience in order to encourage the discussion of new themes, raise interest in the initiatives and to seek new collaborations; they are organised in parallel to COST G8 Management Committee Meetings.
- short-term scientific missions to train scientists of both groups, ie, researchers and practitioners of cultural heritage and the natural scientists. The management looks for original proposals and there is 2500€ available to each successful candidate for projects of a duration of five days to one month
- training schools, such as the one organised in Malta.

One of the working groups is WG3: Degradation processes, corrosion, weathering, which directed the Malta training school. I will simplify the aims and achievements of each EU project presented during the training school and will supply web addresses for further reference.

LiDO (Light Dosimeter for Monitoring Cultural Heritage: development, testing and transfer to market)

Participating countries: Germany, France, Italy, UK and Czech Republic.

Aim: to produce a cheap and easy to interpret light dosimeter that is more sensitive than the Blue Wool Standard (BWS).

Method: research and field trials supported by laboratory investigations assessing different dyes on various matrices/substrates and their response to different lighting spectra and levels.

Results: production of two light dosimeter strips - the LightCheck® Ultra (LCU) and LightCheck® Sensitive (LCS). LCU is on a paper substrate and is for monitoring the exhibition of highly sensitive objects (ISO categories 1, 2 and 3, including works on paper, textiles, parchment, leather, natural history, albumen prints and other sensitive photographic material) that have an annual recommended maximum luminous exposure of 10,000 lux hours [1]. At this number of lux hours per year, after one hundred years a just noticeable fading is predicted. The LCU monitors light exposure to a maximum of 120,000 lux hours. Bleaching occurs when maximum exposure has been exceeded, making the strip redundant as the equivalent luminous exposure (ELE) – or lux hours - is out of calibration range. LCS is on a glass substrate and is for monitoring the exhibition of sensitive objects (ISO categories 4, 5 and 6 including oil and tempera paintings, wood, polychrome sculptures, bone and ivory), which have an annual recommended maximum luminous exposure of 100,000 lux hours in a year [1]. After one hundred years of this annual exposure, a just noticeable fading is predicted.

Uses: both the LCU and LCS are suitable for indoor environments and for preventive conservation planning and surveys, permanent and temporary exhibitions and loan and travelling environments.

Comments: both strips are designed for interior use such as historic house and museum environments, however, the further away environmental conditions are from those used in the development of the test strips (quartz halogen lamp at 500 lux, 23°C, 55% relative humidity) the greater the likelihood of a fluctuating reading. I feel the system is not sensitive enough for the discrepancies to be of consequence – there are only five coloured calibration bands in both products and each band covers a large range in ELE. The strips are instrument-free and cheap (LCU about 8 Euros each and LCS about 15 Euros each) and the following example will help you appreciate their relevance and importance as a tool for planning and monitoring light exposure, and creating light histories for objects. Take, for example, a temporary exhibition of mixed media objects. A 50 lux exposure limit has been requested for the organic/highly sensitive material. To calculate light exposure multiply the hours of exposure by the lux level then multiply this by the total number of days of exposure. In this example, 10 hours of exposure (illumination between 8.30am and 5.30pm) multiplied by 50 lux then multiplied by the total number of days of exposure (90 days) shows that in three months the highly sensitive material will have been exposed to 45,000 lux hours. The predicted colour band for this level of light exposure is 2U or 3U on the LCU calibration card. The U levels in Table 1 represent the five colour progressions from blue to pink on the calibration chart. The 45,000 lux hours thus worryingly represents a 4-5 times increase on the ISO recommended annual exposure of 10,000 hours for very sensitive objects, even with a 50 lux level exposure limit. If the loaned object is returned to the lender for display at similar luminous levels the object will visibly fade in twenty-two years not one hundred!

One criticism of both strips is that the colour rendition on the calibration cards does not accurately represent what actually happens to the dyes on the strips – this will need to be addressed before general distribution.

Website: www.lightcheck.co.uk

LCU	Equivalent luminous exposure (lux hours)
4U	75,000 – 100,000
3U	45,000 – 75,000
2U	30,000 – 45,000
1U	5,000 – 30,000
0U	Below 5,000

Table 1: LightCheck® Ultra colour progressions

MIMIC (Microclimate Indoor Monitoring in Cultural Heritage)
Participating countries: UK, Italy, Spain, Denmark and the Netherlands.
Aim: to compare, contrast and evaluate the degradation patterns of two dosimeter types – one paint-based dosimeter developed in the Environmental Research for Art Conservation project (ERA) and the other a dosimeter of preparation coatings on piezoelectric quartz crystals (PQC). The dosimeters establish damage threshold values to provide an early warning system in order to indicate damaging levels of environmental pollutants in exhibition or storage spaces.
Method: the dosimeters were prepared, exposed and analysed at regular intervals in climates where the air quality and microclimatic anomalies were characterised using established techniques. Measurements at selected sites across Europe will involve relative humidity (RH), temperature, light and pollutants (SO_2, NO_2 and O_3) on a monthly basis for at least twelve months. For the PQC dosimeters two types, with different preparation coatings, were used – an unpigmented egg tempera medium and a varnish coating of resin mastic. Shifts in frequency oscillation of the crystals, caused by chemical changes in the coating, were recorded. All the site dosimeters are being compared with samples of dosimeters aged in accelerated conditions. There is a facility for continuous recording of damage where the PQC modules have a microprocessor to log data for up to a year and download to a PC for subsequent interrogation.
Results: a database on the response of paint tempera dosimeters as developed, in the EU ERA project, is available and awaiting results to include accelerated ageing studies involving pollutants. The database from the two types of PQC dosimeters is still to be correlated and evaluated.
Comments: the continuous monitoring of the PQC modules allows for episodic events to be measured and will offer an interesting comparison with accelerated aged samples' frequency shift results. The egg tempera and resin mastic varnish coatings have a similar damage function to painted surfaces and the degradation patterns might become significant for a mixed media collection. The PQC modules are not available yet but more information can be obtained from the coordinator of the project (see website).
Website: http://iaq.dk/mimic

MASTER (Preventive Conservation Strategies for Protection of Organic Objects in Museums, Historic Buildings and Archives)
Participating countries: Norway, UK, Germany, Greece and Poland.
Aim: to provide conservation staff in museums, historic buildings and archives with a new preventive conservation strategy based on an early warning system that will assess the environmental impact on organic objects. An important part of the early warning system will be the development of a sensor for use with organic materials (EWO-Sensor or early warning organic sensor), preferably one that changes visibly so results can be interpreted locally.
Method: the prototype to the EWO-sensor is a highly visible, free-standing panel, measuring about 40cm across and 30cm high. It houses a number of devices: passive gas samplers for SO_2, NO_2, O_3 and organic acids, a glass slide, spin-coated with a polymer (shielded and unshielded to the environment), paper and silk samples, a Blue Wool Standard strip and temperature and RH loggers. We saw three in the Wignacourt Collegiate Museum, Rabat - two in a gallery (one inside and one outside a case) and one outside the Museum fixed to the wall of an interior courtyard. There are nine other sites with prototypes including Blickling Hall, Norfolk. The field trials are trying to establish a correlation between the effects of degradation on the sensor devices and on the real objects. The sites chosen for the field trials represent a broad geographical area of Europe and cover varying climatic conditions.
Results: research is on-going, with results to be delivered in London in November - December 2005.
Comments: each prototype requires a huge amount of data to be collected and processed (visitor figures are taken into account along with ultra violet spectrometry analysis of the polymer-coated glass slide mounts) so results should hopefully contribute to our understanding of the synergistic effects of the degradation factors on objects as well as sensors.
Website: www.nilu.no/master

IMPACT (Innovative Modelling of Museum Pollutants and Conservation Thresholds)
Participating countries: UK, Norway, Poland and Malta.
Aim: to develop a model to predict indoor concentrations of externally-generated pollutants and their total deposition on the surfaces of objects and other materials.
Method: the model has been developed using SO_2, NO_2 and O_3, calculating the equilibrium to better reflect the slow accumulation of damage to objects from the pollutants.
Results: the model is available through the website (see below). The input variables for the web interface are material type and surface covering in m^2, internal volume in m^3, temperature, air changes per day (or outdoor temperature and wind speed in meters per second [m/s]), relative humidity and pollutant gases. Outputs from the website are the indoor pollutant concentration or indoor/outdoor ratio (I/O ratio) and surface deposition of pollutants to material.
Comments: it is important to be aware of indoor concentrations of pollutants because reactive gases will be deposited and react with the surface of objects and their building environment. This model optimises the use of ventilation systems by helping to predict the lifetime of filters; predictions can save energy and improve pollution control and management in a building. Some understanding of the breakdown of NO_2 in sunlight (on bright sunny days) is needed when using the model because it will not predict interior NO_2 levels accurately on such days.

The controlling factors affecting reactivity and deposition of a pollutant gas on an interface are listed as:
- chemical reactivity of a gas with the surface material
- surface/volume ratio of interior
- air change rate
- amount of free water available for reaction; the more water molecules on the surfaces the higher the tendency for pollutant gases to 'stick'. A 50% and above relative humidity seems to offer the bulk water needed for the 'sticking' of pollutant gases to surfaces.

When I tried the web interface the variable most effective in reducing the total deposition of pollutants in the interior environment on an interface was a reduction in the rate of air changes. Passive measures to reduce the air change rate include keeping doors and windows shut. Sacrificial materials can also be used to absorb pollutant gases rather than installing energy intensive systems such as air conditioning units. I also felt from using the model that a key variable, 'air changes per day', is a difficult calculation to represent accurately and perhaps I should investigate how easy it is to measure wind speeds outside a building, which the web interface offers as an alternative to 'air changes per hour'.
Website: www.ucl.ac.uk/sustainableheritage/impact/

MODHT (Monitoring of Damage to Historic Tapestries)
Participating countries: UK, Belgium and Spain.
Aim: to research the degradation processes operating in coloured fibres and metal threads so that more expert assessments can be made of damage to historic tapestries (of the fifteenth to eighteenth centuries), which can help to provide more optimum conditions for storage, display, proposed conservation treatments and decisions associated with loans and transport.
Method: the tasks include monitoring the molecular weight changes in silk following photo-degradation (Hampton Court Palace), thermo-mechanical testing and thermal stability testing of wool and silk

(Birkbeck College, University of London), the study of mordants and dyes (National Museums of Scotland and University of Edinburgh), the effects of light ageing and the study of mordants and dyes (Royal Institute for Cultural Heritage, Brussels).
Results: as yet unpublished, but the database will correlate analysis from model tapestry samples that have undergone accelerated ageing with historic tapestries – previous records of conservation treatment and their conditions of storage and periods of display will be taken into account. Analysis will also identify fibre deterioration caused by specific stages in chemical processes, such as dyeing (for example the alkali stages in dyeing wool) where the stability of fibres is undermined even before pollutants, environmental and mechanical damage have taken effect.
Comments: the improved understanding of degradation processes, associated with chemical and mechanical damage, will impact on both conservators and historians. I hope results will also help practitioners propose and select treatments, for example offering guidelines on when washing will improve rather than decrease the stability of fibres.
Website: www.hrp.org.uk/webcode/content.asp?ID=706

IDAP Parchment (Improved Damage Assessment of Parchment)
Participating countries: Denmark, Greece, UK, France, Italy, Czech Republic and Belgium.
Aim: to produce a damage assessment programme for parchment, an early warning system and a digitised, user-friendly, parchment damage atlas.
Method: damage assessment is related to decreasing hydrothermal stability, caused by gelatinisation of the collagen matrix, changes in the degree of crystallinity and the physio-chemical state. With considerably disintegrated fibre structures, there is a transformation into a gelatinous substance on contact with, or storage in, moist conditions.
Results: data collection is on-going, but there is a protocol developed from a previous project that provides a set of markers for damage assessment of parchment.
Comments: the programme should provide conservators with a framework for assessing the condition of parchment using visual and non- or micro-destructive sampling. The digitised atlas, using atomic force microscopy, will produce some wonderful images for a database.
Website: www.idap-parchment.dk

Another useful tool I was introduced to was a model to track and predict environmental (temperature and humidity) conditions affecting collections – the Climate Notebook® from the Image Permanence Institute (www.climatenotebook.org). The Institute also offers the Preservation Calculator, an environmental, planning and analysis tool for collection storage environments. In addition, the photographic activity test predicts suitability of enclosures for photographic images and the A-D (acid-detecting) Strips® are dye-coated strips for detecting and measuring the severity of acetate film deterioration or 'vinegar syndrome'. Purafil (www.purafil.com) sell Atmosphere Corrosion Monitors that house copper and silver interfaces that are sensitive to, and monitor, corrosion-forming molecules.

Conclusion

The lectures on the first day covered the general concepts of degradation with particular reference to photographs and paper, paintings and glass. Subsequent lectures looked more closely at the existing tools used to monitor damage and the new tools being developed through the research projects.

Models and tools such as an indicator or sensor that attempt to produce a similar damage function as the original material, whilst taking into consideration some of the variables associated with degradation, are very welcome. They should be used intelligently and usually as part of a preventive conservation strategy remembering that they target environmental degradation and not intrinsic degradation within the material make-up of the object.

A key theme in the presentations was the idea that the tools were being developed with some consideration for, but a partial working knowledge of, the 'synergistic effects' associated with the degradation process. The scientists are trying to unravel the complex interplay between object, pollutant and variables such as: pollutant type, source and concentration, environment and environmental changes, amount and pH of surface water on an object, light, chemical composition and morphology of the object, ventilation rate and exposure times. We also have to remember that objects are subject to soiling, manufacturing processes/chemicals, micro-organisms, animal and human activity, corrosion agents, beneficial effects of corrosion products and dissolution.

The workshop has helped me understand the function, and therefore classification, of the tools, such as whether they are early warning systems, impact or effect sensors, corrosion class coupons, indicators or sensors. I was impressed to discover that any destructive analysis seemed to require increasingly smaller sample sizes (macro and micro samples). Take, for example, pH testing on leather. It is now possible to drill a bore hole 0.2mm in diameter rather than extracting a 0.1g sample as referred to in my report on a leather conservation course (*SSCR Journal* 15/2, p19). The issue of defining what is an 'acceptable' sample size for destructive or non-destructive analysis would produce an interesting debate.

REFERENCE

[1] Tétreault, JT. (2003) *Airborne Pollutants in Museums, Galleries and Archives: Risk Assessment, Control Strategies and Preservation Management.* Ottawa: Canadian Conservation Institute, p138

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