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Conservation of cultural heritage — Integrated pest management (IPM) for protection of cultural heritage

bsi.

National foreword

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European foreword

This document (EN 16790:2016) has been prepared by Technical Committee CEN/TC 346 “Conservation of Cultural Heritage”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2016, and conflicting national standards shall be withdrawn at the latest by December 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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Introduction

Protecting cultural heritage from pests including insects and rodents, and microorganisms such as fungi, is a serious concern for many cultural heritage institutions. This is part of preventive conservation. The challenge of controlling these pests is increasing as several effective biocidal products have been banned by European legislation because of risks to health and environment. International trade, tourism, and global climate changes, with a rising mean temperature, may cause increased activity of microorganisms and an influx of insect pests not formerly known in many European countries. In addition, loans between museums or other cultural heritage institutions are increasing, thereby raising the risk of spreading pests. Previously, there has not been consensus in regard to quarantine and other preventive measures to tackle these problems. For this reason, there is a need for integrated pest management (IPM), a long-term, ongoing and holistic strategy, minimizing risks of damage to cultural heritage and its environment and reducing use of biocidal products. The aim of this standard is to be a management tool, describing IPM policies and procedures.

IPM for cultural heritage follows clear principles including:

— an organization defining roles and responsibilities of staff at all levels;

— comprehensive risk assessment;

— continuous inspection and monitoring;

— preventive measures that aim to physically block pest presence and development;

— remedial measures, prioritising non-toxic methods.

As part of a preventive conservation programme, IPM is as an effective way to reduce damage and cost and to minimize intervention.

In all pest management operations, European regulations and national legislation with regard to protected species and movable/immovable cultural heritage is applicable.

In all pest management operations, European regulations and national legislation on health and safety regarding treatments apply.

If biocidal products are considered for pest control, use should comply with European regulations and national legislation on health and safety regulations.

1 Scope

This European Standard defines Integrated Pest Management (IPM) and describes a comprehensive methodology for managing pest problems for protection of cultural heritage.

This European Standard applies to objects and buildings, housing collections, such as museums, archives, libraries, historic houses and buildings, places of worship, art dealers and auction rooms, art transport and storage companies.

This European Standard does not apply to caves, gardens, and parks.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 15898, *Conservation of cultural property - Main general terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms contamination and infestation are defined in separate terms to distinguish between different pests. In addition to general terms and definitions given in EN 15898, the following apply.

3.1
contamination
presence of fungi, photosynthetic organisms and bacteria on/in materials posing risk to cultural heritage

3.2
eradication
action to eliminate pests

3.3
frass
waste and excrements from insects

3.4
housekeeping
general procedures to reduce the accumulation of dust, dead insects and other organic and inorganic materials

EXAMPLE Cleaning.

3.5
infestation
presence of animal pest organisms on/in materials posing risk to cultural heritage

3.6
integrated pest management
IPM
holistic strategy combining various approaches to reduce and deal with pest problems

Note 1 to entry: The building, the climate in the building, collection management, cleaning, monitoring, documentation, training, and education are all included in the concept.

3.7
isolation
action of keeping cultural heritage items apart in order to prevent the spread of a possible infestation or contamination

Note 1 to entry: If the object is regularly checked for a set period of time, this action is referred to as quarantine, see quarantine.

3.8
monitoring
process of measuring, surveying and assessing the material properties of an object or collection and/or factors of the environment over time

[SOURCE: EN 15898, definition 3.4.4, modified – "or collection" has been added]

3.9
pest
living organism that is able to disfigure, damage, and destroy cultural heritage

EXAMPLE Insects, rodents, fungi, bacteria.

3.10
pheromone
chemical compound that attracts insects

3.11
plotting chart
template to plot the activity and location of pests found by observation or monitoring

3.12
quarantine
period during which isolated objects are monitored for signs of infestation or contamination

Note 1 to entry: Quarantine is also used as a noun, referring to a specific area as quarantine.

3.13
risk zones
classification of areas based on assessing the potential of pest infestation/contamination for prioritising preventive or remedial actions

3.14
staff
persons working on the premises such as employees within the organisation/company, external company employees or volunteers

3.15
trap
catching device for rodents and insects

Note 1 to entry: Can be used in combination with attractants, for example pheromone, light and baits.

3.16
treatment
remedial action carried out on an object or an area in order to respond to an infestation/contamination of one or different pests

[SOURCE: EN 15898, definition 3.5.1, modified – "or an area to respond to an infestation/contamination of one or different pests" has been added]

4 Symbols and abbreviated terms

CFU	colony forming unit
EMC	equilibrium moisture content
IPM	integrated pest management
HVAC	heating, ventilation and air conditioning
HEPA	high efficiency particulate air

5 Integrated pest management strategy and policy

5.1 Introduction to IPM

IPM is an integral part of risk management within an organization as defined in ISO 31000.

When all risk factors for pest presence have been identified, analysed and evaluated, the appropriate action plans shall be prepared. They are aimed at preventing, monitoring, and, if required, treating the infestation/contamination.

IPM strategy is relevant to the needs of the institution, building, collections or environment and should use as much local information and expertise as possible. It should also be achievable in terms of human, financial, and logistic resources.

In order to develop an IPM strategy, the following key components shall be part of successful pest control:

— understanding material vulnerability;

— recognizing pests (the main species and the damage they cause);

— assessing the situation, inspection and monitoring;

— reducing risks;

— solving pest problems;

— post-treatment monitoring.

Continuous communication and consultation, as well as reviewing the action plan shall be integral parts of each step or the IPM strategy.

5.2 IPM policy

The IPM policy shall be authorized by management and included in the institution's policy documents. IPM shall be a standing item on the agenda at both senior management level and in the conservation department, where one exists. IPM shall be incorporated into job tasks of staff, endorsed by policy and supported as a core activity.

If renovating or designing a building, storage or an exhibition, as well as moving or introducing collections or objects, IPM shall be part of the process from the start.

The IPM policy is built on a framework, which defines all roles and responsibilities. It includes various tools, techniques, strategies, and actions and promotes coherence, communication and diffusion of information. The overall responsibility for IPM shall rest with the senior level management of the organization, which:

— defines the objectives to be accomplished;

— supports roles and responsibilities, including contracts with external pest control companies with clearly stated responsibilities;

— establishes communication procedures and use of hierarchical levels;

— provides the necessary human and financial resources;

— provides opportunities for training and development (information and communication).

All of the following aspects of IPM are of equal importance. See Annex A for an example of an IPM policy for a cultural heritage institution.

5.3 IPM coordinator

5.3.1 Position

One staff position shall be appointed as coordinator of the IPM programme, henceforth called IPM coordinator. The IPM coordinator shall be responsible for developing and implementing an IPM strategy. He/she shall act as a project manager, able to collect and communicate information effectively to senior level management and other relevant positions.

The IPM coordinator shall be knowledgeable and experienced in IPM, including identification of cultural heritage pests, pest biology, and treatment methods used for cultural heritage. If needed, special training shall be provided to increase competence.

5.3.2 Function of the IPM coordinator

The IPM coordinator shall have the day-to-day responsibility for the IPM programme, and shall regularly report to management. The IPM coordinator shall be given sufficient time (depending on the size of the collection and specific risks) and an adequate budget to be able to perform the given tasks. Financial resources for IPM shall not be project based but be seen as a continuous part of delivering IPM. Additional funding approval may be required when significant actions are necessary (e.g. during a pest outbreak).

The IPM function shall include:

— analysing risks from biological factors;

— prioritizing preventive actions and/or treatments;

— establishing appropriate policies and procedures for IPM;

— implementation of sustainable and appropriate technical solutions;

— identifying roles and responsibilities of different staff members;

— managing regular monitoring and data collection;

— training staff members and volunteers and presenting relevant information to the public;

— advising subcontractors and external companies on special conditions for cultural heritage (vulnerability, etc.) and overseeing their work within the institution;

— analysing, evaluating and periodically reviewing procedures to improve the strategy.

5.4 Training and education

5.4.1 Information and training

General information on IPM and the purpose and implementation of the policy programme shall be given to all staff. Specialist training on IPM preventive procedures shall be given to all staff responsible for IPM implementation with oral presentations and/or hand-outs, for example explanatory posters with images of pests. A follow-up to the initial training shall be carried out at regular intervals. This includes information about the most common pests that might be a threat to cultural heritage.

IPM literature and help with recognition of pests shall be provided and easily accessible on the institution's intranet or similar. In addition, help with identification can usually be obtained from scientists (biologists, entomologists) in natural history museums, universities, or from private and public consultants.

5.4.2 Health and safety

As part of information and training, all relevant staff shall recurrently be made aware of health hazards regarding pests, for example, allergies and infections. Training shall be given on safe application of treatments. Awareness of former treatments, such as lindane, naphthalene, DDT, and derivates of arsenic and mercury, possibly applied to collections in the past and still hazardous, shall be part of the training. Information shall be given on potential health hazards of treatments. EU and national legislation regarding hazardous substances applies and shall be taken into account in information and training.

6 IPM procedures

6.1 Developing preventive measures

Prevention shall be based on an evaluation of the environment, material composition and condition of objects, taking into account organisational aspects of the institution’s activities.

Evaluation shows what type of biogenous risks the objects are likely to be vulnerable to and defines the priorities of preventive and/or remedial actions to be set up. Monitoring data and mapping, in combination with assessment of the vulnerability of the objects (see 6.2), allows definition of risk zones (very high; high; low; very low/no). For information on risk zones, see Annex B.

6.2 Assessing material vulnerability

Almost any collection and building may contain materials that can be damaged by pests. The inherent vulnerability of objects depends on material, fabrication, historical context or conservation conditions. The vulnerability of the objects shall contribute to the risk assessment.

Materials and individual objects that are at high risk and/or have been infested recurrently shall be identified and given heightened priority in IPM measures. Data collected from monitoring can help to map the scale, type, location and seasonal cycles of a pest problem.

6.3 Assessing outdoor environment

The building as such and its surrounding environment may significantly affect the interior environment and may result in more pests coming into the building. Hazards can be unnotedly be taken into the building by people and equipment travelling through the landscape or by the intake of air for the HVAC. Undergrowth, climbing plants, branches overhanging roofs and roof vegetation are risks that should be managed.

Inadequate drainage will result in increased humidity, which will benefit the growth of pests.

Outdoor equipment, waste bins or firewood shall be properly stored, not leant against outer walls of buildings.

Birds, rats and mice can access buildings housing cultural heritage and cause damage. Nesting, that may harbour insect pests, shall be discouraged and removed. Legislation regarding endangered species shall be taken into account.

Exterior night lighting should be placed so as not to attract pests without compromising security of the building.

Outdoor sculptures or other outdoor features are very vulnerable to pests. IPM measures should apply.

6.4 Blocking pest access

Blocking pest entry to the building shall have high priority and take place at different levels without compromising the integrity and significance of the historic context of the building/interior or building fabric, storage rooms, storage shelving, exhibitions, reading rooms, cafeterias, offices, public spaces, and other enclosures.

The outer perimeter of the building consisting of roofs, attics, cellars, gutters and walls is the first line of defence. It shall be continuously maintained, as shall external pipes. Cracks large enough for pest entry shall be sealed. Protective devices to prevent entry shall be fitted on vents and chimney openings (roof level). Mesh fly screens, meeting fire protection requirements, should be fitted for windows allowed to be opened. Windows should be fitted with blade seals/sealing barriers, or strips/bristle strips of pest resistant materials. Regular inspection and maintenance shall take place at entry points for pests, such as internal pipes, ducts, sewers and drains. Bristle strips should be mounted at all external doors to prevent the entry of pests of different sizes, as well as dust and rubbish from the outside, and should also be used in doorways between collection spaces and other areas (especially in high risk zones). The interior structures (e.g. display cases, cabinets, doors) of the building shall provide a second defence around the collections.

6.5 Setting indoor environmental conditions

Suitable levels of moisture and temperature for the constituents of the objects shall be maintained continuously, and inform IPM. It is difficult to provide guidelines for correct levels of relative humidity and temperature to avoid pests. Recommendations depend on whether a building is heated or not, its use, and other factors such as type of objects, number of visitors, etc. Nevertheless, high relative humidity and high temperature encourage threats of pest infestation/contamination of the objects. Low temperature and/or low relative humidity slow down the development of pests.

Poor ventilation increases the risk of microclimates favourable to pests. Microclimates can occur outside the set climate parameters and shall be properly taken into account, for example behind paintings hanging on exterior walls. When air-conditioning is used, regular control and maintenance shall be in place. An action plan for any malfunction/accident such as a HVAC-breakdown, burst pipes, or water leaks shall be in place.

Light exposure, as well as absence of light, shall be considered relatively to some pests. Depending on the type of light, light-induced heat can create microclimates favourable to pests.

Plants (cut flowers, potted plants, Christmas trees, etc.) brought into the premises are considered risks for pest entry. Staff and sub-contracted florists shall be made aware of this.

6.6 Housekeeping and maintenance

Good maintenance practices and housekeeping can significantly reduce the presence of contaminants and shall be a basic part of any IPM programme. Written procedures shall be put in force describing how to safely clean all areas, including infested/contaminated areas, disposal of dead pests and excrement from insects, birds, rodents, etc. Pests thrive on dust, rubbish, dead insects, earlier infestation/contamination and especially in undisturbed and dark locations. A close examination will usually show accumulation of organic dirt and debris for example in corners, wall or floor angles, behind fittings, under floors and underneath bulky objects, and in cracks. These spaces provide favourable conditions for the growth of pests.

The premises should, as a whole, create an environment unfavourable to pests. Eating and drinking shall be forbidden in storage areas and, if possible, limited in other areas housing cultural heritage. In areas housing cultural heritage where eating and drinking cannot be fully avoided, there shall be guidelines for food handling and cleaning up. Food shall never be stored in offices and other work areas, but strictly assigned to staff kitchens and restaurants/cafeterias. Food sold in gift shops are considered high risk and shall be monitored. Information on food restrictions shall be provided to guests and visitors.

All indoor areas shall be maintained in a manner that makes cleaning and monitoring possible. Cleaning and maintenance instructions shall be specified and adapted for each area containing cultural heritage and checked by the IPM coordinator, who shall add procedures on rubbish disposal, etc., if necessary.

Vacuuming shall be the preferred cleaning method for removing dust and dead insects, also in small spaces and cracks. Vacuum cleaners shall be equipped with HEPA-filters. Vacuum cleaning bags risk being sources of infestation/contamination and shall be disposed of at prescribed intervals. For all areas housing objects, a yearly intensive clean (including behind and under shelves and objects) shall be undertaken.

Staff of relevant external companies shall have basic training in IPM, and before starting work at the premises the external employees shall be instructed by the IPM coordinator. This shall be stipulated in the contract.

If premises are let for corporate entertainment or other activities, written agreements and contracts shall include conditions pertaining to the above.

If premises are shared or co-owned, a mutual agreement shall be in place, clearly stating responsibility and action. A reporting system for all staff of any sighting, of for example rodents, shall be in place.

6.7 Assessing storage and display

Location of storage and display areas shall be assessed and chosen to avoid or minimize risks of pest presence. Storage and exhibition furniture, as well as objects, shall be positioned allowing circulation of air, inspection, and cleaning.

Inaccessible spaces shall be avoided as they may accumulate dust and harbour pests. Exhibition and storage materials, props and furniture shall be as pest resistant as possible and approved by the IPM coordinator.

6.8 Inspecting incoming and outgoing materials/objects

All incoming materials (objects, crates, packaging, etc.), either newly arrived/accessioned or returned from loan, hold the potential of being infested/contaminated, and may cause widespread infestation/contamination in a building or a collection. In order to prevent the spread of an infestation/contamination, a risk assessment shall be made, considering where the object comes from, and whether it is a high-risk material. The appropriate action, for example inspection, isolation,

quarantine, preventive or remedial treatment, should be undertaken in a specific area, isolated from both display and storage areas. A quarantine policy shall be included in the IPM policy.

Cross contamination and infestation during internal and external transport shall be minimized. Objects and packaging sent and received shall be checked for pests and, if infested/contaminated, treated.

NOTE More information on packaging can be found in EN 15946.

IPM shall be part of loan agreements/facility reporting.

6.9 Quarantine

Objects can be isolated, and inspected over a set period of time for signs of infestation/contamination. This process is commonly referred to as quarantine. Restricted access to the quarantine shall be in place. Cross contamination and infestation shall be minimized. If any sign of active infestation/contamination is discovered, infested/contaminated objects shall be treated. Other objects around those infested shall have special attention.

6.10 Assessing pest activity

6.10.1 Inspection of environment, building and collections

Regular visual inspections shall be carried out at set intervals, preferably in combination with monitoring in and around all premises, including outdoors, concentrating on areas where collections/objects are stored and displayed. The purpose of the inspection is to look for pests and indicators of pest activity.

A map, checklist, and appropriate tools shall be used to assist staff with the detection process. An example of a checklist is given in Annex D.

Areas to be checked shall include display areas such as under/behind glass showcases, as well as attics, basements, fireplaces, plant rooms, shops, restaurants/cafés and office areas. Particular attention shall be given to light fittings, windowsills and other light sources to which insect pests may be drawn, as well as dead spaces such as suspended ceilings. Objects, furniture and surrounding areas shall also be checked for sightings of pests.

At the end of each inspection, a report shall be made, communicated to the relevant management level and filed.

If pest presence is detected, see 6.11.

Special information for each pest, see Annex C.

6.10.2 Monitoring

Monitoring is a systematic approach continuously assessing pest activity. This involves strategic deployment of traps and periodical inspection. For information on trapping of specific pests, see Annex C. Record keeping is part of monitoring. Information shall be recorded using a spread sheet, plotting chart or similar, listing date, location, area, trap number, species, stage (adult, larvae, etc.), type (wing, frass, etc.), number of finds, and other pests. A map of the area with locations of traps and detected pests and/or damage shall complement the plotting chart. Other indications or traces shall also be documented, as well as any action taken in relation to the findings and suggestions for the next inspection.

IPM monitoring shall be supported by thorough environmental monitoring.

Data collected from monitoring can help to map the scale, type, location and seasonal cycles of a pest problem.

Actions taken shall be documented as part of record keeping.

Any monitoring or trapping methods might unintentionally affect non-target species, e.g. bats. Measures to avoid this shall be taken.

6.11 Responding to an infestation/contamination

The infestation/contamination and its source shall be identified, located, and assessed, as soon as possible in order to find the appropriate treatment. For short descriptions of different treatment methods, see Annexes C and E.

When infestation/contamination is identified, the objects or area shall be isolated to prevent further spreading. The response shall depend on the type of pest, the nature and quantity of objects, and whether or not treatment of the infested/contaminated area is required.

If there is an infestation/contamination, a comprehensive action plan to control the problem shall be at hand, ready to be implemented. Evidence of pest presence might not constitute an actual infestation/contamination. Knowledge of species and thorough documentation will help define the best response to any findings. The response to an infestation/contamination shall be proportionate to the level of attack and the risk it presents. Intensified cleaning can be an appropriate response. Vacuum cleaning bags risk being sources of infestation/contamination and shall be disposed of immediately outside the building.

Treating a pest-infested/contaminated object might pose a risk of damaging the object. It is therefore of the utmost importance that any treatment is approved upon recommendation by conservation expertise, and if required, authorized by the relevant authority. Methods are continuously being researched and improved and therefore experts should be consulted for the most up-to-date knowledge and expertise.

NOTE Efficiency of treatment can be proven by use of test organisms as reference.

All treatments and actions taken shall be documented and logged. Information shall be provided to all staff about precautions to be taken.

6.12 Recovering from an infestation/contamination

6.12.1 Post-treatment

Thorough cleaning of the premises shall be performed, including cupboards, furniture and treated objects. If the infestation/contamination is caused by environmental conditions, these shall be modified before the treated object is put back in place. Inspection of the area shall be intensified for a period of time following the response to the infestation/contamination to ensure there is no reoccurrence. Daily operations shall be reviewed and altered if necessary.

6.12.2 Evaluation

After an infestation/contamination, an evaluation shall be made. Resources spent, including for example costs for treatment, staff time, extra cleaning, conservation, possible loss, etc., are calculated. If possible causes for the infestation/contamination shall be established. Efficiency of the treatment procedure and response shall be evaluated and new or reinforced preventive measures discussed and decided, as shall training and information for staff, volunteers, contractors, etc. IPM procedures shall also be reviewed, if necessary. The evaluation shall be documented and filed.

6.13 Documentation and record keeping

Data and information, such as analysis, assessments and results concerning IPM, shall be an integral part of the organization's documentation system, for reference and in order to continuously revise and improve IPM.

Annex A
(informative)

Example of Integrated Pest Management policy

IPM policy of [name of institution].

All objects are at risk and may harbour risks for other parts of the collection. At particular risk are the organic materials such as textiles, paper, furniture, ephemera, natural history and ethnographic collections. [Define the objective.]

It is the duty of all staff to be alert and aware of the threat to objects posed by insects and other pests.

An IPM co-ordinator will be tasked with developing and implementing the IPM programme in order to ensure that it is effective, including communication procedures and managerial levels of reporting.

Adequate financial and staff resources will be provided.

Appropriate training and support will be given to staff on IPM basics and pest identification.

All collections entering the buildings will be subject to checking procedures, whether they are own objects or objects on loan.

Materials and fabrics used for decorative and display purposes shall be chosen and checked with care so as not to be food sources for or harbour pests.

Active monitoring programmes will provide information on pest activity levels and locations.

Remedial action will be taken as and when the activity level poses a threat to object or collections.

The treatments used to control pests will be appropriate for the institution and collections and shall be approved by conservation staff.

There will be an annual assessment of the IPM programme to ensure that it is updated to meet changing needs and priorities.

NOTE This policy is based on the English Heritage IPM Guidelines as developed by D. Lauder and D. Pinniger.

Annex B
(informative)

Risk zones

A practical way to understand and map a complex site housing cultural heritage, and achieve effective IPM with limited resources, is to apply the Risk Zone concept.

NOTE Annex B gives an example of a general method based on the D. PINNIGER method [7] applicable to insects.

The key components of the risk zone concept are:

1) Recognize that most buildings housing cultural heritage are likely to have a resident population of pests.

2) Analyse the vulnerability of the collections or objects to pests.

3) Evaluate the risk of collections being attacked by pests.

4) Assign each area in the building to one of four risk zones.

   A. Very high [red]

   B. High [orange]

   C. Low [yellow]

   D. Very low, or none, [green]

5) Determine appropriate protocols for monitoring, inspection, cleaning and maintenance for each zone.

Make sure that Risk Zones become marked on floor plans and sign posted in the area itself.

Annex C
(informative)

Pests - General characteristics, prevention, detection and diagnosis, response and treatment

C.1 Insects

C.1.1 General characteristics

Insects make up a large proportion of the world's animal diversity with many species highly adapted and specialized. Of the many thousands of different insect species occurring in each country, only very few are a threat to cultural heritage and found on a regular basis within buildings. They find a suitable biotope or shelter within the building or enter accidentally. Insects feed on organic material but damage to both organic and inorganic material can result for other reasons (nesting, pupating, etc.). Insects develop through the stages of eggs, larvae, pupae and adults. Most damage is done by the larvae feeding on (for example textiles) or inside (for example wood) the object. Adult insects' primary function is reproduction, but they may also feed on the material.

The time for a whole life cycle can vary depending on the species, nourishment and environmental conditions, from less than one week, up to many years. Most species thrive in warm and often humid and dark environment, and prefer undisturbed conditions.

C.1.2 Prevention

Almost all insects become inactive (do not reproduce or feed) at temperatures below 12 °C. Cool temperatures result in a slower development and can prevent insect damage.

To prevent an insect attack, sealing the building is the first important step (see 6.4). All incoming objects and materials should be pest free in order to prevent infestation. Intensive monitoring should be part of preventive procedures.

C.1.3 Detection and diagnosis

An insect infestation can be detected by visual inspection, and/or by trapping. Different catching devices such as blunder traps, blunder traps with pheromone or other attractant substances, or light traps with glue board (with or without UV) can be used to detect insect pests. Not all traps work for each species in the same way.

NOTE Special care can be taken with the use of UV radiation in cultural heritage collections. Electrocution grids do not allow for subsequent identification and counting of trapped insects.

Trapping gives a good indication of what species are occurring and where to find them within the building.

C.1.4 Response and treatment

If an insect pest infestation is detected, the infested objects should be isolated to prevent the spread of the infestation prior to any further actions. The area should be checked for active infestations and cleaned. The object should also be cleaned after treatment. If the problem relates to the building, further measures concerning the environment, maintenance (for example damp issues), roofs, gutters, downpipes and cleaning have to be undertaken.

There are several options for treatment of insect pest infesting cultural heritage. The treatment method depends on the type of object infested, the species of pest and the available resources. See Annex E for a short description of frequently used treatments for cultural heritage.

C.2 Rodents

C.2.1 General characteristics

The order of Rodentia (rodents) makes up the largest group of mammals, representing approximately 43 % of all mammalian species. Some rodents, the most common of which are rats and mice, are pests and could be dangerous for humans, spreading diseases. These rodents mostly live in urban areas and come into buildings to feed on stored products or food supplies. The presence of rodents is directly related to the amount of accessible food. They build their nests inside the buildings and have a high reproduction rate.

Rodents' incisors grow continuously and need to be worn down by gnawing. This gnawing could damage electric cables, water tubes or insulating material, and cultural heritage. Excrement and secretions from rodents also risk damaging cultural heritage.

C.2.2 Detection and diagnosis

An active rodent infestation can be detected from animal excrement, signs of gnawing activity, sightings of the animals and sometimes smell. Baits and traps can be used as part of monitoring.

C.2.3 Prevention

Any food source has to be considered as a potential attractant to the rodent (risk areas include shops, restaurant, canteen, waste disposal, etc.) and should be made inaccessible for rodents. It should be part of IPM procedures to make sure that all bait stations are regularly checked for activity and bait renewed when necessary. If done by an external pest control company, the process should be checked and controlled as part of IPM procedures. Dead rodents and baits can be sources of infestation.

It is important to seal off the building as much as possible to prevent rodents from entering. Waste should be removed on a daily basis.

C.2.4 Response and treatment

Non-chemical treatments such as break back type traps should be considered first. Increased resistance to rodenticides enforces the importance of preventive measures.

NOTE Professional pest control companies can be covered by a 3rd party certification scheme; see EN 16636.

There is a risk that poisoned rodents can create serious problems should they crawl under floorboards and into dead spaces that cannot be accessed, and die there. This could be avoided by using only trapping devices. During a major infestation all routines for food handling and rubbish disposal should be evaluated, hygiene measures heightened and other preventive measures re-evaluated. When the infestation is under control, traps should be reduced in number and removed again to prevent attracting other animals and pests from feeding on the rodent baits and the dead bodies.

C.3 Fungi

C.3.1 General characteristics

Fungi represent one of the most important agents of contamination for all cultural heritage. The main parameter for fungi development is water in relationship with moisture content and water activity, EMC, relative humidity of the air and temperature. Dust represents a major risk factor in the

development of fungi contamination, because it could increase the moisture content on the surface of the object, act as a food source and accumulate high levels of spores.

Relative humidity above 60 % at a temperature above 18 °C is considered to be the risk range, at which fungal activity may start. Elevated temperatures increase the rate of growth, but development may occur also at low temperature.

Fungi can grow very fast under optimal conditions and cause irreversible damage in a short period of time (days).

Wood fungi can seriously compromise the structural integrity of wooden elements.

C.3.2 Prevention

Prevention against fungal contamination is achieved by maintaining environmental conditions unsuitable for fungal growth with regard to humidity and temperature, avoiding abrupt fluctuations and by limiting the entry of contaminants by efficient air filtration.

Rate of air circulation is another parameter in prevention of contamination, as poor air circulation will promote fungi development if humidity favours growth. High air circulation could prevent active growth. However, in case of contamination, air circulation will spread the contamination unless the contaminated objects are isolated.

Emergency procedures for disasters such as flooding and other water damage, and technical failures should be in place and include drying and dehumidification in order to minimize risk of contamination.

C.3.3 Detection and diagnosis

Visual inspection is the most common way to discover fungal attack. Fungi growth is normally characterized visually by filamentous growth, and/or coloured spots on the surface of the materials. Evidence of damage caused by wood-destroying fungi, such as soft rot, brown rot and white rot, is illustrated by a typical decay pattern of wood.

“Fungal smell” may reveal fungal growth. Other causes of surface bloom can be mistaken as fungal activity, for example salt efflorescence.

To assess risk of contamination, different sampling methods may be undertaken, such as a dry sterile swab to estimate the fungal activity on collections, or air sampling to estimate the air contamination. Counting and identifying CFUs helps to define the risk level and determine the appropriate remedial actions.

It is necessary to confirm fungal activity before any treatment with biocidal products is undertaken. Sampling and cultivating should be performed by companies and/or laboratories using specific biological protocols adapted to the study of microorganisms colonising materials of cultural heritage.

C.3.4 Response and treatment

If fungi contamination is detected, contaminated objects and areas should be isolated to prevent the spread of the contamination prior to any further actions. Active contamination in the immediate environment should be checked, and treated if necessary. The object should also be cleaned after treatment. If the problem relates to the building, remedial measures shall be taken.

Air-treatment systems should be stopped in the contaminated area if they are contributing to spreading of spores within the building and filters checked.

Treatment will always depend on the extent and severity of the attack and the degree of damage and nature of the contaminated object.

The goal of treatment is to reduce the fungal load to the level it was prior to the contamination and to halt the fungal growth. Measures to reduce biological growth on a surface may be by mechanical methods such as vacuum cleaning with HEPA-filter, brushing, etc. As part of recovery from a

contamination, air could be sampled in order to obtain information about the quantity of viable fungi and hence to determine the necessity of treating the indoor environment.

C.4 Photosynthetic organisms

C.4.1 General characteristics

Photosynthetic organisms, such as algae, moss and lichens are common features on outdoor stone, but under favourable conditions they can colonize a large variety of substrates including glass, wood and metal. They colonise the substrate spreading and attaching to the surface. Water and light are essential elements for growth.

Green algae and cyanobacteria can be seen outdoors or indoors. They are microscopic organisms without stems or leaves.

Lichens are a symbiotic association between alga and fungus. The body is a thallus rooted to the substrate surface by hyphae or rhizines. They grow very slowly by extending their thallus outwards. They can tolerate extreme conditions and are regarded as the primary colonizers.

The growth process and vegetative development of these organisms have a direct consequence for conservation. They retain water, which intensifies the chemical deterioration and are responsible for coloured effects on the substrates. They are a food source for microorganisms and animals. Their presence is always an indication of high moisture content of the substrate.

C.4.2 Detection and diagnosis

Algae presence is characterized by green or dark brown colour stains on the base of humid walls in the shade or around drain pipes and at other sites characterized by high humidity. Specialists shall be involved in the identification of species. Identification can be conducted on both fresh field samples and material grown in culture.

Lichens are vegetal organism forming rounded millimetric to centimetric crusty or bushy coloured patches, often having a leathery appearance. They are most commonly grey, yellow, orange, green or black.

C.4.3 Prevention

Particular attention should be paid to the factors that tend to increase biological growth to make the habitat less suitable for photosynthetic organisms. Control can often be achieved through the control of surface wetness by repairing or improving drainage, reducing the sheltering effects of closely situated vegetation, or by limiting the amount of light. Periodic control and regular cleaning should be carried out (mechanical gentle cleaning of the surface using non-abrasive tools).

C.4.4 Response and treatment

The first measure to stop biological growth should be by mechanical methods such as cleaning. After that treatment with biocidal products (algaecide, lichenicide) regular re-application might be necessary. Physical methods such as UV radiation and gamma radiation are methods under development.

C.5 Bacteria

C.5.1 General characteristics

Bacteria represent one of the agents of deterioration for all cultural heritage because of their extreme adaptability to different conditions. They present a wide variety of metabolic types, different kind of growth medium, and organic/inorganic source of nutrition. They are classified by the source of their

energy into heterotrophs and autotrophs, and by the type of respiration into aerobic/nonaerobic. There is a risk that they grow and reproduce extremely rapidly.

The main parameter for bacteria development is water in relationship with moisture content and water activity, EMC, and relative humidity. Dust can support growth of bacteria due to the formation of microclimate niches (high relative humidity), securing a nutrition source and accumulate high levels of bacterial spores.

Relative humidity above 80-90 % is considered to be the risk range, at which bacterial activity may occur in ambient temperature (mesophilic bacteria). High temperature increases the rate of growth (thermophilic bacteria), but development may occur also at lower temperature (psychrophilic bacteria).

Bacteria can create specific structures called biofilms, where they display a complex arrangement of cells and extracellular components, forming secondary structures such as microcolonies, through which there are networks of channels to enable better diffusion of nutrients.

C.5.2 Prevention

Prevention against bacterial contamination will be achieved by maintaining environmental conditions unsuitable for their growth with special regard to humidity.

Emergency procedures for disasters such as water damage should be in place and include drying and dehumidification to minimize the risk of contamination.

C.5.3 Detection and diagnosis

Bacterial contamination is most often characterized visually by coloured spots, but visual inspection is not enough in detection of bacterial contamination. Therefore sampling and cultivating should be performed by companies and/or laboratories using specific biological protocols, adapted to the study of microorganisms colonising materials of cultural heritage.

To assess risk of contamination, different sampling methods may be undertaken, such as a dry sterile swab to estimate the bacterial activity on collections, or air sampling (CFUs per cubic meter) to estimate the air contamination. Counting and identifying CFUs helps to define the risk level and determine the appropriate remedial actions.

Following an outbreak, substantial bacterial contamination on materials or in stagnant water can cause an unpleasant smell.

C.5.4 Response and treatment

If contamination is detected, the main parameters for bacteria development shall be controlled. General measures should be applied to prevent and avoid an extension of the contamination to other cultural heritage objects and to the environment. Emergency procedures shall be applied in case of contamination, for example after failing of HVAC-systems or flooding.

Treatment will always depend on the extent and severity of the attack and the degree of damage and nature of the contaminated object. A measure to stop bacterial growth can be by mechanical methods such as cleaning. As part of recovery from a contamination, air could be sampled in order to obtain information about the load of air contamination to determine the necessity of treating the indoor environment.

C.6 Other hazards

C.6.1 General characteristics

Depending on local conditions, there are other organisms that are generally not considered pests, but may constitute a hazard to cultural heritage and in some cases to human health, for example birds, bats, squirrels, badgers, racoons and foxes.

C.6.2 Prevention

The best option is making the premises unattractive to pests and discouraging breeding and nesting in the vicinity of the building in question for example by the use of bird spikes or metal netting. Specialist advice can be sought in natural history museums, universities or natural history conservation trusts. Nesting bats and bird colonies may be a risk for cultural heritage, but the species may be listed as a protected species in most European countries. There are measures to prevent and discourage bats and birds from nesting, although no active treatment is allowed. National and EU legislation regarding endangered species apply.

Annex D
(informative)

Example of an IPM inspection check list

D.1 Introduction

This example should be seen as a starting point for an organization to create a suitable checklist for the institution to survey an area (room, gallery or store) and make an IPM assessment.

D.2 General information

Date of inspection and person responsible for the inspection and checklist control (name and position).

Before the survey – check and assess the following:

— up-to-date copy of building/floor plan;

— environmental data (temperature, relative humidity, light, HVAC, filtration);

— eradication actions;

— ordinary and extraordinary maintenance;

— latest survey and/or monitoring report;

— reports of incoming and outgoing materials/items.

D.3 Inspection

The environment of the institution will be carefully inspected, photographs will be taken and biological samples collected, numbered and recorded. Look for good points and bad points. Use floor plan or make a rough plan of the layout and mark main features.

List of inspection equipment:

— appropriate personal protective equipment (gloves, masks, etc.)

— sampling material for pest collecting;

— camera;

— note pad;

— thermohygrometer;

— lamp;

— magnifying glass;

— other equipment as appropriate.

Environment – check the following with a view to the risk for pest development:

— temperature;

— relative humidity;

— light;

— air circulation and filtering;

— smell;

— quality of cleaning;

— difficulty of cleaning;

— quality of maintenance of the building and technical installations;

— dead spaces in storage cupboards or display cases and in the rooms;

— material objects are made of;

— vulnerability of materials to pest attack;

— display or storage materials;

— blocking of cases or cupboards;

— list any problem areas such as, ducts, inaccessible spaces, fireplaces, windows, doors, light fittings etc.;

— list other factors such as cafes or staff rest areas;

— list other factors to report (e.g. open window, etc.).

Pests:

— Are there signs of animal pests, if so, what species and where are they?

— Are they alive or dead?

— Are there any traps or baits? Are they correctly placed?

— Are there signs of mould or other growth of microorganisms? Is it active?

— Is there damage to objects? Where are they displayed?

— Are they in display or storage material?

— Are there signs of bats or other protected species? Where are they?

Outside – check the following with a view to risk for pest development:

— attic spaces and ventilators;

— bird nests and roosts;

— signs of bats or other protected species;

— chimneys;

— leaks from gutters and downpipes;

— encroachment of vegetation;

— soil against walls and blocked air bricks and drains;

— other places as appropriate.

At the end of your report, identify and write out on the building plan the deficiencies and risks identified in the areas of the facility inspected. Point out any improper use of biocidal products.

D.4 Recommended actions

Identify actions to be taken to control infestation/contamination and/or reduce risks:

— cleaning;

— repairs;

— proofing;

— treatment of objects;

— treatment of environment;

— improving object and equipment storage;

— change in practice.

Annex E
(informative)

Treatments

E.1 Introduction

There is no single method that can be used for every kind of pest infestation. Below is a short description of different treatment methods used regularly when treating pest infested cultural heritage. New methods are constantly being developed. Since all treatment methods have the potential to cause damage to objects, conservation expertise should be sought before any treatment. Proper measures to avoid human health hazards shall be in place.

E.2 Low temperature

Low temperature is used to treat objects for insect pest infestation, either because they are infested or as a precautionary/pre-emptive procedure. Objects should be packed in polyethylene plastic, excessive air removed as much as possible and the package sealed to avoid condensation. Treatment time may vary depending on temperature, material of the object, pest species and their development stage.

Treating fungi contaminated objects at low temperature will not kill spores, but will delay or temporarily stop growth. Low temperature is used as an emergency response.

Low temperature might affect surface treatments and coatings, e.g. shellac or alkyd on wood and metal.

E.3 Elevated temperature

Objects can be treated at high temperature, either because they are infested by insect pests, or as precautionary/pre-emptive procedure. Relative humidity (RH) around the object should be kept at an appropriate level and air allowed to circulate. No individual wrapping of objects is needed. Treatment with elevated temperature may release previously applied biocidal products to the surface of the objects and off-gas into the indoor air.

Possible side effects are changes of surface of some organic materials, and softening of glues and crystallization of lipids.

Microwave is another method of elevated temperature mostly used by specialized contractors to treat insect infested objects. It provides a rapid elevation of temperature inside the material. The method may cause damage to objects of mixed materials, for example metallic elements and surface finishes.

E.4 Anoxia or modified/controlled atmospheres

This method is used for treatment of objects or materials with a very low oxygen atmosphere in a chamber or tent to kill insects. Different modified/controlled atmospheres include inert gases (for example nitrogen, helium, argon) and carbon dioxide, where nitrogen is the most used. The effectiveness and speed of treatment relies on the control of four main parameters: oxygen level, temperature, relative humidity and exposure time. Anoxia can be provided by dynamic (flushing) or static (with oxygen scavengers) methods. The relative humidity during treatment should be controlled.

E.5 Radiation

Gamma irradiation is ionizing radiation with bactericidal, fungicidal and insecticidal properties. The use is restricted and controlled by specialized companies. Fungi are less sensitive to ionizing radiation than insects, and need a stronger dose. Some materials are sensitive to ionizing radiations.

E.6 Biocidal products

Biocidal products are regulated in the Regulation (EU) No 528/2012 as "active substances and preparations containing one or more active substance, applied in the form in which they are supplied to the user, intended to destroy, deter, render harmless, prevent the action of, or otherwise exert a controlling effect on any harmful organism by chemical or biological means".

The application of biocidal products includes substances that are being used for treatment as well as prevention. The use of biocidal products for cultural heritage should only be considered when there are no other methods. Biocidal products are applied in different forms, such as solids, liquids and gases. Examples are bactericides, insecticides, algaecides, fungicides, and lichencides. Use should be targeted, depending on many factors such as kind of pest, cause and effect, sensitivity of materials or exposure to people.

E.7 Other treatments

Desiccant dusts are silicate products used to physically control insects when introduced in for example cavities, floorboards and dead spaces.

Release of parasitoides which are natural antagonists of some species can be used to reduce and control pest populations present in premises housing cultural heritage.

Traps for rodents and other pests can be used to monitor, reduce or eradicate populations.

Air filtering and decontamination units reduce bacteria, spores, pollen, dust, etc. from indoor air. Equipment not producing ozone (harmful to object materials) should be preferred.

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