7.2. Control of pollutants, mould and pests

7.2.1. Air Pollution

7.2.1.1. Removal of outdoor air pollutants:

Institutions with mechanical ventilation systems have two options for control of outdoor pollutants that ingress the buildings: (a) selection of interior surfaces that react with pollutants or (b) minimising the intake of (polluted) outdoor air. These two factors work together (i.e. as ventilation rate is reduced, proportionally more of the pollutants can react with surfaces) and it is expected that optimum pollutant reduction will balance these effects with the requirements of air supply to building occupants.

Certain interior surfaces are known to react more with oxidant pollutants; for example sulphur dioxide, nitrogen dioxide and ozone are best absorbed by wool carpet, then in decreasing order; wallpaper, latex paint and least by metal or glass.

The effectiveness of reduced intake of outdoor air on indoor levels of urban pollutants will be dependent on the nature of interior surfaces in each building (as well as the tightness of the building envelope) and so it will be difficult to generalise the required degree of ventilation reduction.

7.2.1.2. Controlling emissions of indoor pollutant sources:

Air pollutants arise in buildings from a multitude of pathways, but these are predominantly the following:

(a) ingress of pollutants from outdoor air with air used to ventilate the building or which infiltrates the building through its (leaky) envelope;

(b) emission of pollutants from building materials, furnishings and fittings used inside the building; and

(c) emission of pollutants from appliances (eg. office equipment, heaters) used in the building.

Other sources can include pollutants emitted from the occupants themselves and their activities (e.g. odours, certain volatile organic compounds, bacteria, moisture) or pollutants associated with poor building practices (e.g. inadequate cleaning, ventilation below standard requirements, ongoing condensation on interior surfaces such as air-conditioning ducts and plant or some walls).

Building materials and furnishings are significant sources of indoor air pollutants such as formaldehyde and volatile organic compounds (VOCs).

Removal of air pollutants is discussed in section 10 dealing with display cases and storage units.

7.2.2. Mould

When considering the growth of fungi, which causes mould, it is necessary to examine the substrate on which they grow. It is here, in the surface layers and immediate air layers surrounding the material, that the relative humidity is important.

Another property of organic materials, the equilibrium moisture content (EMC), provides a measure of the amount of water held by the material, but does not indicate how much is available. Different materials absorb and desorb moisture at different rates, and when at equilibrium with the surrounding air, at a given RH of the air they will have different equilibrium moisture contents. For example, leather is higher than wood which is higher than wool and cotton. With a certain fungal species, mould will grow on leather at 76 per cent RH, on wood or wool at 85 per cent and on cotton at 96 per cent RH.

Due to the small diurnal changes in temperature in hot humid climates, the use of air movement and ventilation will have little effect on the temperature, and therefore the use of heat (increase T with resultant decrease in RH) is not an appropriate means of lowering the RH around an object and its mould growth potential.

Mould growth should not be a problem in hot dry climates as the relative humidity will in general be too low. When cool air is brought into the museum during the night, although this will have a higher RH than the daytime air (kept out by sealing the building), when this strikes the still warm interior surfaces the RH will be lowered. So here there is the opposite problem, ie low RH levels and possible desiccation of objects.

For temperate climates there can be low or high levels of RH depending on the location and time of the year, and mould growth is a potential problem.

From the above it can be suggested (as positive evidence is not available) that in hot, humid and temperate climates, if it is possible to bring into the museum air of an RH of 70 per cent or lower for say at least one hour per day, in most cases this should be sufficient to prevent the growth of mould. This period would normally be during the day, and external climatic data at the museum site is required to determine what is possible. Air intake fans to the museum could be connected to a humidistat to take in air when it falls below say 70 per cent RH, or museum staff could be asked to open windows and turn on fans when the RH was appropriate. Care should be taken if the building is shaded or of massive construction as the temperature of the internal walls may be lower than that of the incoming air, in which case the RH at the surface would be increased, nullifying the process. Normally air would be taken in during the day, not at night as being cooler would have an even higher RH.

If mould is found, the source of moisture must be determined, as if from a leaking roof, condensation or rising damp etc., this can then be rectified. If mould still persists then other means of reducing the RH as discussed in section 8 should be considered. Fungicides should only be used as a last resort.

7.2.3. Pests

Insect Pests can be a major problem for museums, archives and libraries. Even with repeated treatments for insect infestation, if an appropriate and safe environment is not provided for its storage or display, the insect problem will re-occur. It is therefore important for the museum personnel to develop an Integrated Pest Management Plan for preventing the insect problems from re-occurring (section 7.2.3.1.). It could be a number of simple, practical steps to start with, which eventually can be improved.

7.2.3.1. Integrated Pest Management

It is always preferable to avoid an insect problem than to deal with it once a problem occurs. An overall IPM approach will be the best alternative. This program does not depend on the use of pesticides to prevent or control insect problems, but instead involves the implementation of a number of measures including:

(a) Physical Control: the alteration of the environment by physical means making it hostile or inaccessible for pests. For example, insect screens, seals around doors (section 7.2.3.3).

(b) Cultural control: the manipulation of the pest's environment to make it less favourable. This can include relative humidity and temperature control, good housekeeping etc.

(c) Control without using pesticides: eg freezing, heating or low oxygen treatment of insect infected objects.

(d) Monitoring and evaluation of the effectiveness of the treatment.

(e) If unsuccessful, use chemical control: appropriate selection and application of least harmful pesticides.

(f) Monitoring and evaluation of the program.

The first line of defence against pest infestation must be the building, then the display case or storage unit. All objects brought into a museum should be carefully inspected to determine whether insects or other pests are present. This may be simple for metals, glass and ceramics, but difficult for complex organic objects, natural history specimens and where packing materials have been used. If possible these objects should be left in quarantine (establish an insect-proof room for this) to determine if there is any sign of insect activity. To be on the safe side it would be better to treat them on the assumption that they do contain pests, using one of the recommended procedures mentioned above. If these practices are not carried out, any form of pest control at the building level will be a waste of time it will help to keep pests in the building, brought in from outside.

7.2.3.2. Insect traps

One of the most valuable tools of an IPM program are regular, thorough inspections. During inspections many insect problems can be discovered before too much damage has occurred. Inspections can, however, be time consuming, especially in large collections where the organic, and even some of the inorganic, material is at risk from insect attack. It is here that insect traps can be of assistance.

Blunder traps are non-specific traps which assist in identifying any insects present within the collection. In spite of the presence of a food attractant in most traps, the capture is largely due to the location and placement of the traps where insects are common. The most common traps are usually made from a piece of cardboard, one or both sides of which are sticky, but lots of other types are available.

Trapped insects can be identified using one of the many insect identification books which are available or by contacting the entomology department of a museum. Through correct identification it is possible to learn whether or not the insect poses threat to the collection, what type of material(s) are likely to be infested and what to look for (ie: adults or larvae).

Many traps now incorporate a pheromone. Pheromones are chemical messengers, similar to hormones within our bodies, which are produced by insects to communicate messages. These chemicals when passed from one insect of the same species to another, cause a certain response, either behavioural or physiological. Some examples of these are :

- aggregation pheromones, which may attract both males and females (e.g.: to a food source);
- -trail marking pheromones (such as those used by termites and ants); and
- -sex pheromones (which cue for mating).

Pheromones are now used in many traps as an attractant to lure insects into them. Any insects within a certain distance of the trap will ‘home’ in on the odour and will become trapped. By checking these traps on a regular basis it is possible to get an indication of the presence (or absence) of a specific insect within the monitored area. Pheromones are now available commercially for a number of insects including museum pests such as cigarette and drugstore beetle, common clothes moths and cockroaches.

7.2.3.3. Control of insects

There is a wide range of insects that can be a problem for collections including beetles, moths, termites, cockroaches, and silverfish. Some fly, others crawl, they have different life cycles and there are different species and sizes of insects. This makes it difficult to use a standard approach to any preventive system. Insects require food, water and shelter for survival and a museum can provide all of these.

First, it is important to determine the species and habits of insects that are likely to be present in a museum. Such information should be available from a nearby Forestry Commission, entomology department of a natural history museum, university or Department of Agriculture, or from commercial pest control companies. This can be supplemented by a careful survey of the inside and outside of an existing building, plus the use of insect traps to determine which insects are present. Then by studying the different insect species, their life cycles and habits, it is possible to propose a number of general and specific approaches to prevent them from entering the building.

Building surrounds

Do not plant trees or shrubs close to a building, and use non-flowering plant species. Remove ivy and any other form of creeper from exterior walls. Gravel or paving close to the building avoids the need for watering, which in turn keeps moisture away from the building and in addition it is non-attractive to insects and rodents. Leaf litter, tan bark and other organic mulches can harbour insects, therefore good garden hygiene and maintenance is essential. Obviously all garden rubbish must be kept well away from the building and removed or disposed of as soon as possible.

Buildings are often illuminated for aesthetic or security purposes. This can be a problem. If at all possible do not attach lights to a building as any light will attract insects. Close to a building the lights, if used, should be sodium lamps, which through their low UV output are not very attractive to insects. Away from the building use mercury vapour lamps, which due to their high UV output will draw insects away from the building.

As with garden refuse, garbage from the museum should be contained away from the building in a unit that is insect and vermin proof, and again disposed of as quickly as possible.

Planting and landscaping

There is a wide range of trees, scrubs and herbs which have insecticidal or insect repellent properties. If appropriate to the gardens and landscape around the museum (this may not be possible with an historic house museum and with historic gardens etc), a selection of such plantings could be included. A list, using their common names is given below:

Cotton lavender (*Santolina*) Lavender	Both plants are reputed to repel moths, carpet beetles and silverfish.
Neem	This plant is a native of western Asia where its insecticidal properties have been known for some time. It acts as a repellent and a natural Insect Growth Regulator, which disrupts insect growth and moulting. Registration for Neem in Australia is still pending.

Rosemary	This common culinary herb has a long history, as early as the 11th century, for its repellent action on many household pests. The plant itself is a repellent, not just the commonly used herb sachets.
Pyrethrum Daisy Feverfew	A plant with a long history of planting and refining for its repellent and insecticidal properties. Feverfew has similar properties to Pyrethrum, although the active ingredient is weaker.
Western Red Cedar Redwood Jam Acacia White Cypress Pine	These trees are recommended as resistant to termite attack.
River Red Gum Blackwood Bloodwood Blackbutt	These trees, as well as the above, are resistant to some extent to borers.

Wattles are the least favoured species for planting in the grounds of a museum as they are very prone to insect attack.

Building layout

Careful thought given to the layout of the building as regards its different functions at the design stage makes it possible to build it for insect control. For example, keep areas attractive to insects away from the collections whether in storage, on exhibition or with curators/conservators. The areas that attract insects are kitchens, restaurants/cafeterias, workshops (particularly carpentry), bathrooms and toilets (source of water). If possible all food processing and serving facilities should be in a separate building or at least confined to one area of a single building with direct access from outside.

It is important to have a quarantine room where collections are held on arrival at the museum, or after treatment for insect infestation. This should be adjacent to the loading bay. Making the loading bay insect proof is a challenge. Obviously doors should be closed as much as possible, and a positive pressure within the bay, pushing air out, may be of some assistance. Weather strips across the bottoms of doors would also be of benefit. The laying of a residual insecticide such as boric acid plus silica dust across an entrance to help keep out insects is a possibility, but this is questionable as they will rapidly get bridged by local foot or vehicle traffic.

Entrance doors are the other main avenues for insect entry, therefore, they should be kept closed as much as possible. Although more expensive, revolving doors or a double set of doors are useful in this regard. They also prevent loss of conditioned air (by whatever method) from within the building, or entry of heat/ humidity/dryness from outside.

Building fabric

If the materials of construction of the building are insect proof such as brick, stone, concrete or steel, then the likelihood of insects entering the building are drastically reduced compared with wooden structures, for example.

The problem with all buildings is that they have entrances and holes through which services such as electricity, water, sewerage, gas, etc., are supplied. These provide ideal access for insects which take advantage of different types of hiding places, from tiny crevices to large spaces. The benefits of these hiding places are two-fold; they provide concealment which can allow quite large populations of insects to develop unnoticed and renders them difficult to find, and the protection afforded makes eradication of insects, by whatever method, more difficult.

Doors should be kept closed at all times when not in use, and weather/draft excluders provided, not only to keep out the weather but to help exclude insects. Windows when closed should fit tightly, and if opened should be screened against insects.

Fly screens are readily available. From the literature the minimum sizes of holes to prevent entrance by different insect species are as follows:

2.3mm	House flies, blowflies
1.15mm	Mosquitoes
0.85mm	Sandflies
0.7 1.7mm	Beetles (depending on the species)

These can be controlled by the common mesh sizes of 10 20 gauge, which have apertures of 2.27-0.853mm respectively. There may still be insects such as species of the dry wood termite and wood boring insects which are smaller, and known to get through standard fly screens.

Screens should be an important feature for windows, especially in office areas that are left open to allow air movement by prevailing winds and natural ventilation. Screens should also be applied to all vents and drains through which insects could gain access to the building. Such screens will keep out all pests, but may need to be of a stronger material, or be covered with a wide mesh metal screen to exclude vertebrate pests.

All joints of the building and spaces around pipes and ducts should be carefully sealed with a flexible caulking compound. This will not only prevent insects entering the building but will remove breeding spaces, and in addition reduce entrance of outside air with its changes in temperature and relative humidity. Ideally the building should be as tight as possible.

Gutters and down pipes should be external to the building. Here building design is important, as potential problems which can be created by guttering e.g. box gutters, should be avoided. Such gutters are known to overflow or split in time creating moisture problems, which apart from promoting mould growth also encourages insects. Regular maintenance and good housekeeping, as always, is of paramount importance.

It is also important to remove bird nests, which can harbour insects. Other insects such as bees and wasps, although themselves not a problem as regards the collections, their nests, when vacated are again a possible source of insects and they should be removed. They can also be a nuisance to visitors.

Housekeeping and sanitation

Most insects require only a small amount of water and food to survive, consequently the dust and moisture invariably found in buildings such as in store rooms, around plumbing etc., can be sufficient to feed insects once they are in the building. It is therefore essential that such sources of nutrition are kept to a minimum. As with the building structure, all crevices and cracks in interior fittings, around vents, ducts and piping etc., should be sealed. Prevent condensation forming on cold water pipes or tanks by the use of insulation. Regular inspection and good housekeeping which will remove dust, ensure leaking pipes are fixed quickly etc. will help to control possible problems.

It is obvious that food must be kept away from working, storage and exhibition areas. During construction, good building practice and supervision, plus informing workers why they should remove food scraps and building litter, could go a long way towards eliminating this food source for insects.

A new building may settle and move for a certain time period after construction is complete. Therefore, regular building inspection is important to monitor any movement, and then carry out remedial work such as sealing any cracks that may have occurred.

Fittings and structures within the building

It is one thing to prevent insects entering the building through the building fabric, but what about when insects have already entered, either through a missed crack in the building, brought in with an object and not properly inspected or treated, through an open door, or with a person or supplies entering the building? If insects are in the building it is necessary to prevent them moving freely about and also remove all sources of nutrition.

Within the building, storage units and exhibition cases should be designed with gaskets so that they close tightly. Take care with the choice of gasket material to ensure that chemicals harmful to the collections are not released (section 10). As mentioned earlier, sealing cracks and crevices of internal structures will remove breeding and hiding places for insects. The use of weather seals on interior doors, although looking a little unusual will also help in this regard. It is particularly important to have good seals between public areas such as exhibition rooms, sales areas, food services etc., and collection storage.

Good housekeeping, particularly vacuuming (requires high efficiency filter) is important. Dusting without vacuuming only moves dust, which can be an insect nutrient, from one area to another. The contents of a vacuum bag should be checked to determine whether any insects have been collected. These bags should be immediately disposed of outside the building. Putting them in an interior garbage bin is not sufficient as any insects collected may escape.