



Air Pollution

Museums and galleries bring together collections and the public. On most days of the year visitors enter the building. Their surroundings must be at a comfortable temperature and the air they breathe must be fresh. People's health and safety require a certain kind of environment - and the law insists that institutions provide it. Fresh air is therefore allowed to enter the museum through open doors and windows, or is drawn in by means of a ventilator.

Museum objects also require a certain kind of environment, which includes an atmosphere free of dust and pollutants. Unfortunately the outdoor air, brought in for the wellbeing of visitors and staff, is often polluted. This is particularly the case in towns and industrial areas, where cars and industry produce harmful pollutants. Materials used for the construction of the building, display and storage may also give off harmful substances that pollute the air, and furnishings and visitors add to the pollution with fibres and skin flakes.

This factsheet is about the pollutants that can be found in outdoor air. The effects of gaseous pollutants generated indoors are not discussed here, as they are outlined in a separate factsheet: *The Effects of Materials used in Storage and Display*.

Gaseous Pollutants

Outdoor air pollution is associated with towns and industry, and is almost entirely caused by the burning of fuels in power stations, factories, vehicles and heaters. When fuel is burnt, the sulphur content combines with oxygen in the air to form **sulphur dioxide** (SO₂). Sulphur dioxide, which is also naturally present in outdoor air, has become the most significant pollutant in Britain. It reacts with the ever-present water molecules in the air to form **sulphuric acid** (H₂SO₄).

Car exhaust fumes produce **nitrogen dioxide** (NO₂). It forms into **nitric acid** (HNO₃) with water from the air. Nitrogen dioxide also forms **ozone** (O₃) and **PAN** (peroxyacyl nitrate) in combination with sunlight (these pollutants are therefore referred to as 'photochemical smog'). **Ozone** is not just a man-made pollutant but is also naturally present in the air at a height of 20-30 km, where it protects life on earth from harmful short wave ultraviolet radiation. However, the increase in ozone at ground level is such that it has become a threat to both people and objects.

All these gaseous pollutants can be divided into two main groups, according to their physical properties: substances that are acidic and substances that have an oxidising effect.

1. Acidic Substances

Acidic substances are corrosive, they affect the surface of materials such as metals and calcareous stone. They cause hydrolysis in cellulose materials: a process of decomposition by moisture, which induces the breakage of molecular chains (loss of strength) and eventually the disintegration of the affected material. Sulphur dioxide and nitrogen dioxide are mildly acidic. Sulphuric acid is a strong and corrosive acid. It does not evaporate and leave the affected material even after the source of the acid has been removed. Nitric acid is also a strong acid, but it evaporates and is therefore less likely to cause problems in the long term.

Acidic substances can have the following effects on museum items:

- limestone, marble and other calcareous materials readily dissolve ("acid rain");
- iron corrodes;
- leather suffers from "red rot": it loses its strength and flexibility and eventually is reduced to powder;
- cotton, linen and viscose deteriorate rapidly, they become very weak and brittle;
- wool and silk are weakened;
- paper objects become increasingly acidic, they become yellow and brittle;
- the silver in photographic images yellows and fades;
- gelatin, paper and the filmbase of negatives degrade;
- sulphur dioxide affects some modern dyes and pigments.

2. Oxidising Substances

Oxidising substances bring about oxidation reactions. The process involves yellowing and the formation of acids in organic materials. These acids cause cross-links in the molecular structure of the materials, making them very brittle. Double bonds in carbon molecule chains are broken, thus damaging almost all organic materials.

Nitric acid, ozone and PAN are powerful oxidants. Ozone in particular is very reactive.

Oxidants can have the following effects on museum objects:

- dyes and pigments fade;
- rubber cracks;
- textiles become brittle;
- paint binder is attacked;
- the tarnish rates of metals such as silver, copper and iron are increased;
- they cause pyrite decay ("fossil disease"): pyrite, present in many fossil materials, contains sulphide components. These are oxidised into sulphur dioxide. The result is yellow and white efflorescence, cracking of the specimen and sometimes total destruction.

Particulate Pollutants

Burning fuel also produces sooty and tarry **particles** which are then dispersed into the air. Large particles are abrasive and may cause surface scratching. Some particles may be large and heavy enough to settle in still air (dust or grit). Others are so small that they remain suspended until trapped or held down on some surface by electrostatic attraction. They can enter display cases, deposit on objects, and soil the surface. Particles are usually **acidic** due to absorbed sulphur dioxide and therefore affect all acid-sensitive materials. Acidic particles are hygroscopic: they attract water and cause corrosion of metals. They may also contain **traces of metals** such as iron, which can speed up the deterioration of organic materials.

Special attention should be paid to situations where food is prepared (restaurant or coffee-shop areas). The preparation of food may produce "wet" or oily particles, which can be so small that they travel through a building before they are deposited. It is important that adequate air extraction is used in these situations.

New concrete emits **alkaline** particles. They darken oil paint films and discolour some dyes and pigments. Protein materials, such as wool and silk (and the hair in thermohygrometers), lose their tensile strength.

Coastal areas are affected by high levels of **salt crystals** in the air. Salts absorb water from the air, creating droplets with high salt concentrations. These will corrode most unprotected metals. High moisture levels can also support the growth of micro-organisms even when the surrounding appears quite dry.

Textile fibres and fragments of skin can be an attractive food source for insects.

How to Reduce the Risk of Damage Due to Pollution

First of all it is important to find out what the pollution levels in your area are. The Environmental Health Department of the Local District Council can be contacted about pollution levels. When levels of pollution appear to be high, or it is noted that dust and dirt build up rapidly within the museum, it is necessary to take action.

The most effective solution is to **prevent any pollutants from entering the museum building**. This will only be possible when the building provides an effective envelope for the collection, so that no uncontrolled air can enter. It is important to ensure that doors and windows close properly, and that a policy is developed for the opening of doors and windows. In general, the building should be free of any leaks or drafts (but it should be noted that some sort of ventilation is necessary for the fabric of the building).

Furthermore the air that is brought into the building with ventilators should be fully controlled. This can be achieved by:

- filtering out particles (but not with electrostatic air cleaners, as they produce ozone and aid the conversion of sulphur dioxide into sulphuric acid);
- filtering out gases, either with a water spray system (not effective for ozone) or with active carbon filters.

Such air filtering systems can be expensive to install and run, and require ongoing maintenance. It may be necessary to install ducting throughout the building, which involves substantial building work. Recirculating the air once it has been filtered will help increase the running of the system in a cost-effective way.

It is not always possible to achieve a situation free of pollutants by the methods described above. Limitations in budget or building permission (historic buildings) may make it difficult to install major air filtering plants. However, the main aim should be to **prevent harmful substances from reaching the object**. There are several options that keep costs and alterations to a minimum.

- Place the objects in an enclosure. This can be a cupboard, a storage box or a display case. It is important that only those materials are used that do not give off harmful substances themselves and do not create an adverse micro-climate. Avoid open display and storage, and use dust covers for items that cannot be stored in boxes.
- Use materials that act as a buffer, such as (buffered) acid-free paper and board, but do not use buffered material near items that are affected by the buffering agent, such as photographic materials and textiles.
- Maintain a regular housekeeping programme, to prevent the build-up of dust, dirt, fibres etc. throughout the building.
- Use room air cleaners. A room cleaning unit consists of a filter or filters mounted in a box with a fan to draw the room air through the filter. It can remove both particulate and gaseous pollution. Room air cleaners do not require any ducting and may be a suitable alternative for listed buildings and historic houses.
- Minimise air ventilation in areas used for the storage of collection items.

It is important to note that museum objects themselves may also give off harmful substances. Military displays often contain uniforms and metal items. The sulphur compound in the wool may affect the metals. Modern organic materials are most likely to emit harmful gases. For instance, badly processed photographs may give off acidic or sulphuric gases that cause brittleness and discolouration of the paper, and cellulose nitrate ("celluloid") objects release vapours that speed up their own deterioration. These processes particularly occur when the objects are kept in a confined space (such as a display case, a self-sealing polythene bag or a plastic box), where a concentration of the harmful vapour is allowed to build up. For these objects an exception should be made: they are best displayed in cases that allow air-exchange, and should be stored together in a separate part of the storage area where there is adequate air-exchange.

For further information contact the Scottish Museums Council's Conservation Service.

This is one of a number of related Factsheets written for the Council's member museums covering aspects of the care and conservation of collections. For full details of Factsheet titles consult the Council's Publications List.

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