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Archive Buildings In A Tropical Climate And With Low Resources (Original in Spanish)

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I would like to underline the difficulties involved, because of the diverse and specific nature of the language as it is used in each nation in Latin America, in drawing up a final text in Spanish. All efforts were made to produce one that could be understood throughout Hispano-America.

Aware of the complexity involved in a project of this size, I would like to express my gratitude to the authors and advisers for their constant and valuable understanding and collaboration. I would also like to thank the directors at ALA, and in particular Ms. Virginia Chacón, for giving me the opportunity to be part of this fascinating project.

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Introduction

In my capacity as President of the Asociación Latinoamericana de Archivos (ALA) and as a member of the Executive Committee of the International Council on Archives (ICA), I presented a project for approval during the latter's meeting in Ottawa (Canada) in 2001. Its principal aim was the publication of a practical manual for the construction of archive buildings or installations in countries with tropical climates, offering low-cost solutions to meet the conservation needs of archives.

The proposal sought to constitute a committee of Ibero-American experts, including archivists, architects and conservators, who would be responsible for carrying out an exhaustive study on the special characteristics of archive installations and buildings in such areas. The study was to take into account the specific needs and problems arising from the climatic conditions with regard to the organisation, conservation and dissemination of documents on any medium, in order to find solutions based on low-cost technologies. The ALA would assume responsibility for coordinating the project and providing the ICA with a final text in Spanish, which the latter would then translate into other languages to disseminate to archivists throughout the world.

The proposal was welcomed enthusiastically by the Executive Committee because a practical guide to the design, adaptation or construction of archive buildings would benefit the many archives located in tropical climes, especially a guide that was the result of the study, discussion and reflection of a multidisciplinary team of experts.

Not only did the Executive Committee approve the three year project, but it also became its main sponsor. Thus, 2001 witnessed the creation of the Committee of Experts, under the general coordination of the President of ALA. It was initially made up of archivists Jaime Antunes da Silva (Brazil), Ana Virginia García de Benedictis (Costa Rica), María Berarda Satabarría Abraham (Cuba) and Stella González Cícero (Mexico); conservators Ingrid Beck (Brazil), María Cecilia Arce (Costa Rica), Juan Ramón Romero (Spain) and Patricia Sánchez (Mexico); and the architects Alfredo Britto (Brazil), Rogelio Salmona, (represented by Sara González) (Colombia), Mauro Fernández (Spain), Pierre Noilly (France) and José Helué (Mexico).

This invaluable group generously contributed their knowledge and experience and held their first working meeting from 3 to 7 December 2001, hosted by the General Archive of Mexico. From January to October 2002, each expert sent their contributions to the manual to the President of ALA and to the technical and editorial coordinator, Ms. Sara González Hernández, employed by the General Archive of Colombia. Ms. González was responsible for organising, adapting and complementing all this important material and sending the different versions of the manual to all the experts for comments, suggestions and modifications.

The second meeting took place in Rio de Janeiro, Brazil, on 15 and 16 November 2002, hosted by the General Archive. It was attended by the archivists Antunes, García y Salabarría; the curators Beck, Romero and Sánchez; and the architects Britto and Fernández, together with Ms. González, the technical coordinator, and me. Unfortunately, some of the experts could not attend for a variety of reasons.

This meeting saw a third overall revision of the future manual, with corrections made as required and new material presented. Thus a 'final draft' was made which also incorporated collaboration and suggestions from the Brazilian conservators María Aparecida Remedio and Franciza Toledo, and the Costa Rican architect Álvaro F. Morales. This was sent for approval to all the experts that had taken part in the early months of 2003 before finally being published.

Thus, after almost three years of intense work, the Asociación Latinoamericana de Archivos is proud to present the international archive community and, in particular, those responsible for archives in the large and varied tropical regions, this practical guide to the design, construction or adaptation of buildings for archive use, that takes into account not only the climatic characteristics of such regions, but also their political, social and economic context.

I would like to express warmest congratulations and gratitude to all the experts who collaborated on the project and to the Technical Coordinator for their unselfish support, professionalism and responsibility, and for demonstrating that efficient multidisciplinary projects are possible; and, of course, I would also like to thank them for their friendship.

Finally, one must emphasise the need for more detailed study of these exciting subjects. With the collaboration of other specialists, we hope to enrich, extend and complete a new version of this manual in the near future.

Virginia Chacón Arias
President of the Asociación Latinoamericana de Archivos and
General Coordinator of the manual
National Archive Director of Costa Rica

Chapter 1 The Documentary Tower Of Babel

1. 1. The Archive As A Centre For Preserving, Organising And Disseminating Documentary Heritage

Besides its traditional functions of compiling, organising and preserving documentation, the archive as a whole now has a new mission: to achieve maximum social benefit from the information and heritage it stores. The archive should be seen as a company offering services to its community and the government itself.

Formerly in archives, mass public access was unthinkable and, consequently, archival institutions were traditionally somewhat isolated. Since the end of the 19th century, especially since the Second World War, issues and difficulties related to historical research, together with methods, work systems and the interests of social scientists, have changed.

Furthermore, citizens' demand for access to archives in general is growing, as is awareness of their importance as a fundamental part of a nation's cultural heritage. Consequently, the documents are seen as belonging to humanity and fortunately the attitude of contempt for the past and devotion only to the present is being left behind.

William Rosenberg, Vice-President of the Research Division of the American History Association, has stated that "archives are the depository of national memories and consequently the identity of nations". Thus, not only do archives play a role in the enabling the study of documents, but they can also influence how a country's memory, and its national collective identity, are established.

Therefore, it has been considered that this manual should put forward basic recommendations for the construction or adaptation of buildings for archive use, especially those storing documents of permanent value, which constitute the documentary heritage of a nation, region or municipal district. The option of the building acting as a store for administrative and central archives is by no means discarded. Documents can exist in different media such as paper, photographs, disks, microfilm, microfiche, magnetic media, CDs, etc. As a result new technologies are required to enable them to be consulted, and their very diversity increasingly means that primary sources have to be disseminated utilising audiovisual techniques, conferences and exhibitions.

Only through a creative, continuing, respectful and enriching dialogue between archivists, conservators and architects will appropriate solutions be found for the construction or adaptation of buildings for use as archives. This dialogue should not exclude other professionals or users, who may make valuable contributions. The archivist and the conservator will propose those requirements that they consider necessary for the archive to function correctly and only then will the architect study and propose the best solutions to meet these needs, based on technical appraisal and critical observation and analyses of the experience of other archives.

1.2. The Building

Archive buildings, like others involve architectural, aesthetic, emotional, environmental and construction-related problems. Each case is particular. If we accept that architecture is influenced by both geography (the characteristics of the location) and history (not only the emotional content, but also the experience of society in building construction and aesthetics), then the archive should respond to specific realities. Archive buildings cannot be 'mass designed' in an attempt to make them valid for anywhere in the world. The globalisation of architecture is unacceptable. However, although strict universal standards are not possible, there are general principles which must be applied when considering the technical and functional requirements of the building, the climate, the lie of the land, the location in town or city, the history and the community's expectations.

Above all, archive buildings are works of architecture and any project should answer to two fundamental premises: aesthetics and surrounding space on the one hand, and functionality on the other. Architecture needs to provoke emotion, to evoke a liking for the building and the town or city in which it is situated. The construction of an archive, as that of any institutional building, is an urban problem: it must contribute something to the town; it must be an addition to the town, appreciated and understood as a whole and, in time, it must become a work of art, valued and admired. As with all architectural problems, this is one of ethics, because what we do now conditions the future. The building can contribute to the development of a town or city, or to a specific area in it, but great harm can also be caused. The second premise, that of functionality, makes the building respond correctly to its intended use. However, it should reach further: a public building should be as transparent in its parts as it is in its whole. It should also be transparent with regard to the town, creating a characteristic and enriching urban landscape

The archive building must stand out in the town's architectural catalogue. The town, which has become the greatest of humanity's inventions, is the result of the sum and dialogue of its buildings. Above others, buildings with cultural functions, such as archives, libraries and museums, must be more prominent reference points, due to their sense of permanence and their role in the education and structuring of society.

The building to be used as an archive, at any level, whether it be municipal, departmental, state or national, *cannot be just any old building*. It must have character. It is architecture as a cultural phenomenon of fundamental importance to the work of a nation that should provide this characteristic. The origin of the building is unimportant; what matters is its architectural quality. It can be a period building (Paris), a modern building (England), the result of a change in use (a wide variety of examples), a prison (Mexico), a church (Finland), a mint (Brazil) or a new building (Colombia or Costa Rica). Besides the need for it to be optimally functional, of the correct size and endowed with all the technical requirements, the archive building must prove to be highly attractive to citizens, transmitting a sense of continuity and security.

Like all institutional works of architecture, the archive building is part of our heritage. Pierre Francastel, the great sociologist of art, said that all architecture is a document. It is not an archaeological document, nor a pictorial document, but rather a document of space, representing the ideals, emotions and experiences of a society. It must contain deep social meaning, or it will have no value whatsoever. This is the true importance of such an aesthetic, cultural and spatial emblem.

1.3. THE USERS

Besides history, other disciplines, such as architecture, sociology, education, health, economics, political science and engineering, can find the information they need to rewrite their past, or that of a country's most important institutions in the material kept in an archive. Public participation in the work of an archive is on the increase. From the 1980s onwards, the institutional willingness of most archives to allow their material to be accessed by an increasingly wider public, including unspecialised visitors with a variety of cultural interests, has become evident.

Accordingly archivists and archives must be equipped and prepared to make the public aware of the rich variety of their documentary collections by implementing systematic outreach policies. They must always seek to increase possibilities for access and use of the documentary wealth they store by extending the areas of use. Thus, the archive must both reinforce its institutional image among its traditional users and attract new ones.

Archives have diversified their services, increasing dialogue and interactive collaboration with different users each day. The scope and area of research has been widened. Now documents are not only used for academic purposes, but can also be used to study more "practical" subjects, such as events, people, road infrastructures, the development of communications, industry or trade, scientific progress, urban expansion, everyday life, etc. They are used for specialist publications, dissemination and other non-traditional tasks. Maps, stamps, photographs, texts, calligraphy, drawings and signatures increasingly are amongst the materials used by the media to reinforce and illustrate their messages. Archives have frequently been used to provide the central theme for scripts for documentaries and films.

Furthermore, various archival media (slides, cassettes, CDs, videos, microfilm, and magnetic media) are consulted in the teaching of history. They provide evidence of, among others, the colonial administration (such as royal letters patents); population processes (censuses); economic activity (taxes, trade relations, production); statistics on a variety of themes; everyday life; and past manners of thought.

Nowadays, it is difficult to imagine an archive without large public areas, as well as comprehensive information services, reading rooms (for study or research), exhibition halls for all kinds of material, for adults, schoolchildren and specialist public; auditoriums, training and advice rooms; a shop selling publications and archive-related objects, as well as the usual rooms for administration, archive storage, preservation, reprography, classification and dissemination, etc.

Chapter 2 The Building

2.3 INTRODUCTION

Given that archives are not considered a priority in the public services in a majority of countries, buildings are often neither suitable nor adequate. It is usually the case that archives seek to optimise available funding to meet their requirements, while faced with reductions in their budgets. Given that all archives seek the best conditions for the preservation, classification and use of the historical heritage, for those situated in areas with a tropical climate this presents increased challenges. In the majority of archives in these regions, problems caused by adverse climatic conditions often coincide with the adoption of expensive and generally obsolete technologies.

It is necessary to undertake some preliminary works, in order to establish what is necessary in a building suitable for archives, in which collections of historical, administrative, judicial or cultural importance can be kept in optimal conditions, to be catalogued to international standards and easily consulted.

2.2 PRELIMINARY WORKS

Those charged with the construction, or conversion of a building for an archive need to undertake some initial tasks and to establish some basic parameters, which may be summarised as follows:

- to draw up a checklist of requirements, which includes a description of the building complex and its dimensions;
- to be aware of all the legal requirements that will affect any future construction or conversion;
- to establish the geotechnical situation of the area: its capacity, the depth of the aquifer, climactic variations etc.;
- to take into account any effects urban development may have had on the area, through provision of services such as electricity, sewerage, roads, telephones etc.;
- to check if any potential conversion for use as an archive, is affected by restrictions on its use and modification; the load bearing capacity of the building and the type of building materials used; climatic changes throughout the year; what public services are provided; the surface area of the building and the possibility of expansion. Only when the amount of work needed to be done to convert the building for use of an archive is known, can the costs be calculated and the criteria established to complete the conversion;
- to ensure the necessary economic, human and technical resources are available;
- to draw up an inventory of the documents to be stored in the archive encompassing the quantity, the physical condition and the different media.

2.3 LOCATION

This is always a subject for debate, but, in general, it can be argued that a building intended for an historical archive, as opposed to that intended for a library or any other public building, does not need to be in the city centre, since the majority of users are not members of the general public, but specialist researchers. On the other hand, administrative archives, which are more frequently consulted, do need to be in the administrative centre of a city.

It can also be argued that for economic reasons, an archive should be situated outside an urban centre, where land costs are lower. In addition, because of the need to conserve documents in many different media, it is vital that all archive buildings and their constituent parts are situated away from contaminated areas, such as urban or industrial centres. It is usually thought that archive buildings should be situated in the urban centre, the seat of the central administration or the government, as this would offer them a greater level of protection. All these considerations notwithstanding, an archive building, whether historical or administrative, needs to be situated on a site with easy access and, above all, in a cultural or administrative centre. Once the building is in use, the best conditions for users and visitors must be established. In so doing, the institution will gain the support of its users. In order to establish the best location for an archive building, whether historical or administrative, especially in countries with a tropical climate, the following factors need to be taken into consideration.

2.3.1 Climate

A definition of 'tropical' covers regions situated in the equatorial zone with conditions ranging from humid to savannah or desert. In such areas there are considerable variations in temperature and relative humidity, heavy rain, wind and oceanic currents, and specific conditions affected by altitude, geomorphology and vegetation. Climate can also be affected by human action; for example devastation can be caused by a policy of slash and burn, diversion of rivers, the building of dams and the process of urbanization (see annex).

2.3.2 Vegetation

Vegetation is an important resource in the improvement of environmental conditions. It can contribute to air purification by forming a barrier against the wind, atmospheric contamination and noise. It can diminish light infiltration and reduce temperature. However, problems can be caused by an increase in humidity brought about by a concentration of vegetation around the building, with the attendant risk of insect proliferation.

Trees should be planted at a safe distance from the building to avoid the risk of damage from roots and branches, an increase in humidity in the walls and a proliferation of micro-organisms. Trees to be avoided include those susceptible to attack from insects (such as termites and ants), those that produce flowers, fruit and large leaves (which are not easily biodegradable) and all of which can attract birds, insects and other undesirable animals. In addition, fruits and large leaves make building maintenance difficult and can block drains and pipes and damage roofs and guttering.

2.3.3 Geology

The topography, soil conditions and other geological factors need to be investigated. Land intended for an archive building ought, ideally, to be elevated and dry, easily drained, not at risk of flood or landslide, be free of termite infection and to afford easy access.

The following are recommended when choosing a site for an archive building, to minimise risk. The area should be far from:

- humid and swampy terrain;
- seas, rivers or sites subject to flooding;
- regions subject to fierce winds or storms;
- regions subject to dry winds or sandy soil residues;
- industrial sites which produce dust or other contaminating substances;
- chemical factories;
- electricity or nuclear plants;
- high tension power lines or stores of inflammable and explosive material;
- traffic terminals, airports etc.;
- areas of busy traffic, noise and environmental contamination;
- zones of known seismic activity;
- commercial and industrial centres and large car parks.

2.4 Planning Of The Building

2.4.1 Introduction

The first thing to be considered is whether to convert an existing building, or to have a new one.

It is often the case that an existing building has to be converted, whether for budgetary or availability reasons,, or simply because of a lack of alternatives. However, because older buildings were not designed for the storage and conservation of archives and documents, they often have many drawbacks and adapting them to archive buildings is often more difficult than starting from scratch. Problems with older buildings present projects with some difficulties. Often, the modification of a building for archive purposes requires consolidation and reconstruction works, which can increase the budget. In addition, the floor loadings may need to be strengthened to meet the minimum requirement of 1.2 to1.5 ton/m².

Before any decision is taken to build or convert an existing building, a cost/benefit analysis should be undertaken, comparing the costs of both options. This should not be restricted to the financial costs: environmental, administrative and cultural considerations should be given equal weight when considering the future benefits.

An architect should be involved from the very beginning of the process, in order to evaluate not only the conversion, but also the architectural characteristics of the building designated to be the archive. In some countries buildings preserved as part of the country's architectural heritage may be preferred.

Above all, the process of converting an existing building will be an architectural project, depending on the level of deterioration. Any building restrictions and recommendations applied by the departments charged with oversight of the historical patrimony, at local, national and international level, must be taken into consideration.

The fundamental role of the architect is to use his skills to ensure compatibility between the defence of the historical patrimony and the needs of the archive. Any expansion needs should be taken into consideration, while bearing in mind any legal limitations on the use of and alterations to preserved buildings.

Given that countries in tropical zones often have scare resources and archives are a low priority within local administrations, lessons can be learned from countries with more experience. In general, it has been seen that a new building designed specifically as an archive allows the space to be used more efficiently, offers greater security and often is less costly than converting an historic building, which might require costly structural works that are often difficult to achieve. The archive building should always be separate from others around it.

2.4.2 Size

First, the size and layout of an archive building will depend on the type of archive for which it is intended, whether that be historical or intermediate. When this is known, calculations can be made for specific areas such as storage for documents in all media, work and administrative areas, laboratories, searchrooms, social areas (cafeteria, auditorium, training suites), and for utilities. Second, it is vital to know the volume of material held by the archive and to make an allowance for future expansion. Another important aspect to be considered is the services provided in the building: consultancy, training, reprographics, conservation and restoration, sales of publications and outreach activities. It is worthwhile making generous calculations about the possibility of future expansion of the building. A forecast of the likely growth over a 50-year period should be made, to allow for the calculation of the amount of shelving required.

As a general rule, when calculating the division of space within an archive building, it is recommended that:

Storage areas for all types of documents should have a minimum area of 50m², which should be 60% of the total building area. The public areas should not constitute less than 25% of the total area.

2.4.3 Areas within the building

An archive building needs accessible non-public and public areas.

2.4.3.1 Non-public areas

These consist of administrative areas, laboratories and workshops.

- *Administration* comprises the offices of the Director and the Senior Management Team. Strongrooms and workshops should be accessible from these areas. Access by visitors to these areas should be restricted and controlled.
- *Archivists' Offices* should be situated between the strongrooms and the working areas.
- *Processing areas* include those to receive, clean, and disinfect documents and to classify and list them, as well as restoration and reproduction workshops. These areas need to have good lighting, whether natural or artificial, and to have temperature and relative humidity controls.
- *Work areas for service personnel* ought to be in the centre of the building, to allow staff to have easy access to all parts of the building, and to enable them to carry out the large number of tasks necessary for the efficient running of the service.

- *Workshops* including those for photography, binding, restoration etc. ought to be at the same level as areas of selection, classification etc, and always be provided with the necessary levels of security.
- All working and social areas need good levels of lighting, whether natural or artificial, good levels of aeration and appropriate levels of temperature and humidity to ensure the well-being of staff and users of the archive.
- *Photographic laboratories* ought to have clean rooms for filming, making enlargements, developing and editing and for the storage of paper, films and chemicals. With the exception of that for editing, rooms should be windowless, but have independent climate control and extraction systems. Access to darkrooms ought to be through antechambers to avoid light penetration.
- *Microfilming laboratories* ought to include rooms for preparation, filming, processing, duplication and quality control, for making paper copies and for editing. Planetary cameras and enlargers can be up to 3,20m in height, and this needs to be taken into consideration where these are to be installed.
- *Ancillary rooms* for photographic processing, microfilm duplication, storage of chemicals and those which house copiers and other electrostatic machinery need to have extractor fans, in line with regulations for the control of volatile materials.
- *Plant room:* it is worthwhile planning ahead for the installation of heavy equipment, which often requires special floor loadings, a 3 phase electricity supply, circuit breakers and independent hydraulic tubing.
- *Strongrooms*: given the importance of these, they will be dealt with in Chapter 3.
- *Materials stores* need to have a minimum area of 50m².
- *Exits and emergency evacuation routes* need to be clearly signposted and easily accessible for all areas of the building.

2.4.4.2 Public areas

- These are areas dedicated for public use; they should be designed to be comfortable, and be furnished with all the equipment and services necessary to conform to international standards on security and accessibility for the disabled. It is recommended that these areas occupy 25% of the total area of the building. They can be classified as follows:
- *Reception:* this should be situated in the principal vestibule of the building and should be the central control for access and supervision, as well as acting as the information centre and the visitor reception area for promotion of the service and the sale of publications.
- *Reading room:* it is estimated that the average space required per visitor is 5m², which takes account of the space needed to consult maps, plans and digitised documents, microfilms and audio visual material. This room needs to have furnishings and equipment necessary to consult documents in different formats, as well as being provided with a specialist library. It is vital that it should contain a temporary document storage area, a security system and offer clear vigilance over those consulting the documents. Finally, it should have means of protecting the documents.
- *Exhibition area and annexes:* these should be situated near the reader reception area and should be used for exhibitions, projects, meetings and conferences. It should be constructed as one large modular room, which can be divided into smaller units where various events can take place simultaneously.
- *Services:* these should also be situated near the main entrance to the building, and contain a cafeteria, toilets, telephones, a commercial area and a first aid room.
- All these public areas should be completely separate from the other areas of the building, to prevent the public gaining access to the working areas.

2.4.4.3 Entrances

Separate entrances for employees, the documents and the public should be considered, with restricted access to the work areas and strongrooms. Entrances should consist of the following:

2.4.4.3.1 Public entrances

- All should be equipped with ramps, handrails and wide doors to allow access for the disabled.
- Pedestrian and vehicular access should be signposted in conformity with international regulations.

- All employees, users and visitors to the building should be made aware of all evacuation routes.
- Pedestrian and vehicular access should be controlled either by guards, or by means of electronic systems, in order to be able to identify all those who enter the building.
- Vehicular access and parking should be away from the reading rooms and strongrooms.

2.4.4.3.2 Access for documents

- There should be one entrance for documents which leads directly to a fumigation area, to avoid the possibility of fungal or insect infection.
- The document reception area should be large and be covered to protect the documents from wind and rain.
- The loading bay should be one metre above the floor, to allow for easier handling of loads. It should be equipped with ramps to allow access to small vehicles.

2.4.4.3.3 Access for staff

- Access to working areas should be restricted to employees of the archive and should be situated near the staff areas, with cloakrooms, restrooms, cafeterias and parking.

2.4.4.3.4 Parking

- These areas should be situated outside the building and never in the basements, for reasons of security and because carbon monoxide produced by cars could affect the documents. They should allow for easy access to the building and should be clearly signposted.

2.4.5 Site and construction

The site chosen should allow for the possibility of expansion, be load bearing, have stable thermal conditions and allow for the construction of a building of high architectural quality.

2.4.5.1 Construction materials

A huge variety of materials can be used when constructing or converting a building for use as an archive and it is important to have a clear understanding of the building regulations and principles which allow them to be used in different circumstances, as well as experience in using them.

One of the basic functions of archives is to protect the historical heritage and to allow access to it. The choice of building materials and equipment should be subject to rigorous specification to prevent accidents, environmental problems and to ensure the preservation of the material. The building ought to be as watertight as possible and have the optimal climatic control that can be achieved in the area where the building is constructed.

'Architects should not impose their will over their clients: the archives and their employing administration'. Neither architect nor builder should seek to impose their will. Each project requires their support and not the imposition of their views over those of the clients. All architectural projects should blend into the area, to integrate with its surroundings.

When selecting materials, it is necessary to be aware of how they react to climatic conditions, with the huge changes in temperature which occur in tropical areas, with their resistance, their costs and to have experience in working with them.

It is vital to select solid, durable materials and, at all costs, to avoid those which deteriorate with humidity. Although there are means of dealing with such materials, this would add greatly to the costs. Abrupt changes in temperature can induce expansion and contraction, which inevitably causes gaps to emerge in the structure. It is vital to select materials that are fire and humidity resistant, do not allow dust or other environmental pollutants to accumulate, are easy to clean and which can be maintained and conserved without the intervention of costly technical processes.

As a general recommendation, the use of wood should be avoided in the construction of buildings. Where its use is inevitable, it ought to be fire proofed and treated to withstand insect attacks.

There follow several recommendations on the selection of materials which can be used in different parts of the construction.

2.4.5.2 Foundations
Materials should be capable of absorbing humidity through capillary action, e.g. stone, brick and steel.

2.4.5.3 Walls
Priority should be given to non-porous materials, which are easy to clean and disinfect and which will avoid dead areas difficult to access and clean.

- External walls should be treated to avoid heat loss.
- Internal walls should be of a light colour to avoid the risk of heat and humidity, as well as to allow for ease of cleaning and conservation.

In general, walls should be treated with materials which do not contain formaldehyde or other chemical pollutants. It is recommended that they should be fire resistant, noise proof and have an isolated temperature control.

2.4.5.4 Facades
As these help avoid the infiltration of solar rays and limit the effects of heat and humidity within the building, it is recommended that:

- they are treated with impermeable substances.
- they should preferably be painted or covered in a clear colour, with reflective properties to lessen the transfer of heat to within the building.
- the climate of the area should be taken into consideration when deciding on the composition of the facades (hollow or solid).
- large expanses of glass should be avoided, as they do not offer protection from climatic variations, and they can cause the building to overheat
- facades with the greatest number of openings ought to face the side least exposed to the sun, and those most exposed to ought to seek methods of isolating the temperature control, and providing natural ventilation.

2.4.5.5 Floors
These should be made out of washable materials, be non porous, such as an industrial tile or ceramic, in order to prevent a build up of dust.

2.4.5.6 Windows
Even allowing for the benefits of light and solar heat as a microbicidal agent, the documents need to be protected from ultraviolet rays which can penetrate windows. It is therefore recommended that:

- a maximum of 20% of the façade should be limited to openings.
- openings should not be placed on the side most exposed to the sun and other forms of natural energy
- openings facing in the direction of humid or marine winds should be avoided at all costs.
- where there is no natural climatisation, windows should be opened to allow natural ventilation and air circulation.
- small mesh filters should be installed to prevent insects entering the building.
- curtains or filters to prevent solar rays should be installed.

2.4.5.7 Doors
These are important in the climatic control of the building and it is recommended that:

- those which allow entrance to the building should be of solid construction and fitted with a self-closing mechanism;
- when it is necessary to leave them open to improve air circulation, they should be fitted with inner doors constructed with a thin mesh, to avoid insect infiltration.

2.4.5.8 Roofs
It is recommended that:

- these should be constructed from an impermeable material, resistant to heat and humidity;
- these should be sloping, to avoid the accumulation of water and assist in the deflection of the sun’s rays;
- a ventilation system ought to be installed in the roof space, in order to maintain a constant temperature.

2.4.5.9 Ventilation

Archive buildings in tropical climates need to have good ventilation and air circulation for the users and the documents. To protect the latter, it is vital to maintain a constant temperature and relative humidity, which will assist their conservation.

2.4.5.10 Insulation

Archive buildings ought to be equipped with systems which insulate areas against great variations in heat and humidity and against noise and environmental contamination.

2.4.5.10.1 Heat insulation

Construction methods can be used to deal with the temperature within a building, especially in the composition of the external walls, which can greatly limit the transference of heat. Heat insulation can be achieved either naturally or artificially:

- *naturally*, by increasing the thermal inertia within the building, which allows the temperature and relative humidity to be maintained at a constant level. This can be achieved by varying the thickness of the exterior walls. This method is often used in older buildings restored or converted for archive use, where the structure is not tailor-made, or where the materials used in the construction are friable, or extracted from rock mixed with lime or a similar material, such as clay;
- *artificially,* by using a system of air conditioning.

Alternative methods have been used to achieve thermal inertia in different areas, such as:

- construction of very thick exterior walls to allow maximum insulation in the building;
- the construction of a double wall system outside strongrooms specifically, to limit the amount of heat directly transmitted;
- leaving a space of 30cm between the external and internal walls, to create a chimney to allow the vertical circulation of air;
- to obtain good thermal insulation related to external conditions, it is necessary to have good air flow in the spaces between floors;
- cables should be covered with thermo-insulating material, which should be fire proof and sealants should be impermeable against water and steam, with thermal insulation and a barrier against steam built into the external faces of walls;
- external walls should be sealed with an impermeable substance in order to form an air pocket, which improves the capacity for insulation. This process should also be extended to the lower zones to create homogeneity in the insulation of the whole building.

2.4.5.10.2 Insulation against humidity

The problem of humidity is very severe in tropical climates, and can be brought about through frequent and torrential downpours of rain, high water levels, winds, ponds, accidents etc. To avoid the latter, the following means need to be used:

- protection against rain can be improved by fitting roofs with overhangs which will protect the facades of the buildings from diagonal rain. This type of roof also serves to control changes in temperature between the exterior and interior of the building, by creating a shade for the walls.
- sloping roofs are better adapted to fierce precipitations, and need to be equipped with down pipes, to avoid the possibility of water collection leading to floods within the building.
- roof tiles should be water proofed and insulated. Water proofing of roofs is very important, to avoid any risk of damage to the documents.
- the use of light colours should be used on the roof to help to reflect solar rays.
- doors and external windows should also be provided with medium sized eaves, to protect them from diagonal rain.
- the building needs to be protected by construction of a sanitary ditch, separating it from the humid terrain, and the archive ought to be constructed on pillars. This avoids an increase in humidity caused by capillary action and helps to protect the building from rodents, insects and termites.
- as has already been mentioned, when choosing a building site for an archive building this should not be situated near sources of natural water, such as rivers, lakes or oceans.
- external walls which form a vacuum should be equipped with a system of filters which lessen the penetration of humidity from the exterior.

2.4.5.10.3 Noise insulation

Artificial soundproofing is expensive; therefore it is advisable to select the terrain for an archive building in a tranquil area. The presence of trees and green areas around a building can assist in avoiding noise pollution, though trees should not be planted too close.

2.4.5.10.4 Insulation against contamination:

The construction of a double exterior wall, with filters, will assist to a large extent in diminishing the presence of environmental pollutants, dust and gases, within the building. If a double wall has not been built, a priority must be the installation of filters on all doors, windows and other openings.

2.4.5.11 Lighting

The maximum natural light available is advisable for all work areas, reading rooms, and exhibition areas. In every case, all windows and other places open to solar rays should have UV filters fitted.

2.4.5.12 Hydraulic, sanitary and electrical fittings

All conductive pipe work for rainwater and residual water, and all cabling should be separate and exterior to the building.

Electrical installations should be sectored with independent maintenance, and covered in aluminium tubes.

Hot and cold water supply, both filtered, ought to have sufficient volume and pressure for purpose. The calculation of the volume and pressure ought to take into account the number of employees and the workflow.

Where hydraulic equipment is necessary, floors should have drains and be on an incline sufficient to allow the water to flow away.

2.4.6 Protection, control and vigilance

Archive buildings should be constructed to allow for control and vigilance to be ensured. These can either be achieved in the design of the building, such as through open spaces, or by mechanical methods available on the market, such as lightning conductors, close circuit television, mirrors, personal supervision and a system of access tickets for both employees and users.

Chapter 3 Strongrooms

3.1 INTRODUCTION

When considering the conservation of historical documents in particular, one of the most important criteria to be taken into account in weighing up the alternatives, is the physical condition of the archive building and the surrounding area. Best use should always be made of the prevailing natural conditions (temperature and relative humidity), and the use of expensive air conditioning systems should be avoided as far as possible. It should always be borne in mind that documents come in many forms, each one of which require specific conditions for preservation.

Strongrooms for archival material require particular attention, especially if one considers that practically all the factors which can cause degradation, whether chemical, physical or biological, are related to high levels of temperature and relative humidity and, more particularly, with variations in both. Architects need to examine the best methods of reducing levels and maintaining stable conditions for temperature and humidity, and avoiding the increase of pathogenic agents. In general, strongrooms need to be well built, functional and secure.

3.2 GENERAL CONDITIONS FOR THE CONSTRUCTION OF STRONGROOMS

In tropical climates, strongrooms built to store documents of whatever type need to conform to the following general conditions:

- they should be isolated from the rest of the building by means of corridoors, protected against all risks from outside the building and have easy access to laboratories, workshops and reading rooms via vestibules and be equipped with fireproof doors;
- they should contain the necessary emergency exits as deemed necessary by local regulations;
- all parts of the strongroom should be clearly signposted, in agreement with local regulations;
- they should not be built underground because of the problems that can be caused by flooding, the difficulty of isolating such areas, the porous quality of the walls, all of which would require mechanical ventilation, dehumidifying and air-conditioning systems;
- construction in the higher storeys of the building offers more advantages, though they need to be protected and isolated from excessive natural light;
- when a lift is necessary to reach the strongrooms, it should not open directly into the room, to avoid the risk of fire and/or infection from micro-organisms;
- work areas should not be set up within the strongrooms;
- fire detection and extinguishing systems should be installed, and access should be limited to authorised personnel;
- temperature and relative humidity should be maintained at a constant level appropriate to the type of document being stored;
- depending on the climate of the country, it may be necessary to install mechanical methods to control ventilation, climatic conditions and dehumidification, in order to achieve stable temperature and relative humidity. If this proves impossible, it will be necessary to resort to natural systems of aeration and ventilation and augment the thermal inertia of the building in order to minimise the variations in temperature and humidity.

3.3 CAPACITY AND SPACE FOR STRONGROOMS

It is estimated that around 60% of the total space of an archive building should be devoted to strongrooms, and this space should be calculated on the basis of the amount needed at the time the building was planned, plus expansion for 50 years.

The space available will depend on the type of shelving chosen: fixed, mobile, mechanical, high racking etc. The types of shelving will determine the quantity of material that can be stored, and it is important to remember that mobile shelving allows between 40 and 60% more storage capacity than fixed shelving.

For security reasons, it is recommended that the size of a strongroom should not exceed 200m², to minimise the fire risk. The height of each bay should be 2.70m, of which 2.20 m should be shelving and 0.50 m left free for the installation of ducts normally for air and/or security systems. Given that the greatest needs of a strongroom are for ventilation and aeration, it might be worthwhile looking for spaces with a large volume of air, always remembering that the greater the space, the more energy will be used to control the climate, and, if fire were to break out, then flames would spread more easily.

Strongrooms should be constructed on various floors; the structure should be of pillars and covered in reinforced concrete, a material with high fire resistance.

Strongrooms should be built to support the weight of a fully shelved room of 200m². If available resources allow the purchase of compact shelving, then it should be remembered that the floor loading requirements will be substantially higher than for rooms equipped with static shelving.

In order to cope with full shelving, floor loadings need to be:

750kg/m²	for static metal shelving, 2.20 m high
1.300kg/m²	for mobile shelving.
800kg/m²	for library shelving.
1.600kg/m²	for mobile library shelving.

3.4 STRONGROOMS FOR SPECIFIC TYPES OF DOCUMENT

3.4.1 Introduction

No matter what type of document is being stored (Annex 2), it is important that strongrooms offer the following general conditions:

- appropriate systems
- humidity, temperature, light and ventilation control
- protection from atmospheric pollution
- protection from infestation
- protection from fire, flood and risk of theft
- good design, with areas clearly specified and compartmentalized.
- use of materials which can assist in the control and stabilization of the interior conditions, in preference to using artificial methods of control.

Therefore, in countries with a tropical climate, where economical solutions always have to be sought, it is important to try to use materials which will aid the isolation of heat and humidity, absorb humidity and contaminants and even filter and diffuse light, including when methods of ventilation are considered.

The organisation and lay out of areas and spaces for the storage of documents or the installation of other furniture, must be subject to various criteria, such as:

- configuration of the land and regulations governing it, in order to decide on a horizontal or vertical layout
- making the project fit the available budget
- technical difficulties
- specifications by archivists and conservators who are going to use the building
- maintenance of the building.
- frequency of documentary transfers and consultation of the material.

See further Annex 3.

3.4.2 Paper

The storage areas for paper documents ought to be situated in the zones of the building which offer the best natural ventilation, and where there is the best climatic stability..

Solutions available are the introduction of natural ventilation, as well as isolating the strongrooms from humidity, using thick walls and internal corridors, to allow for the free circulation of air.

Thick walls are the best means of ensuring stability in levels of relative humidity in the archive strongrooms and, where there are variations, corrective measures can be introduced, such as controlled ventilation and easy air circulation to avoid condensation. To achieve this latticed windows, gardens, arcades and pergolas can be created around the building.

Now the best method is seen to be the construction of simple buildings, using low cost natural resources to make use of the environmental conditions for the preservation, with low cost maintenance.

It should be remembered that paper is best preserved in temperatures which vary from 15ºC-25ºC, and with a relative humidity of between 45%-65%. These conditions can also apply to other graphic material, such as maps, plans, sketches and drawings, but the latter need to be stored on large shelves, in acid free boxes, or using specific map shelving, and must always stored horizontally.

Other requirements have to be taken into account:

- avoidance of direct natural light
- avoidance of direct artificial light
- avoidance of contamination from dust or other substances
- control of infestations
- drawing up of an evacuation plan, to prevent/control fire and flood
- installation of security systems.

3.5 STRONGROOM FURNITURE

3.5.1 Shelving for paper documents

Utilisation of shelving is the most common method of storing documents, and it can be used to store files and books vertically, in order to make their classification and consultation easier. Such shelving can also be used to store plans, paintings and all types of documentary material.

In a modern archive, metal shelving is the most appropriate for document conservation, whether conventional (static), easy to build and dismantle (where the individual shelves are not screwed into the uprights), or compact; these are the types of shelving most readily available, and the conventional, fixed shelving is the most economic.

3.5.1.1 Shelving material

There are alternatives, dependant on the budget available:

- Rolled steel: shelving should be made from cold rolled steel, treated with enamel at a high temperature, to create an anti corrosive finish. This is the most common and easily obtainable type.
- Plastic: this should be used whenever possible, as it requires minimum maintenance.

The use of wood ought to be completely avoided in archive buildings.

3.5.1.2 Dimensions of shelving

It is recommended that each aisle of shelving should be a maximum of 10m long, between 2.20-2.40 m high, with shelves 90cm long and 40cm wide for outsize documents. Shelves ought to be able to withstand a load bearing of 80kg/m². Steel posts, whether structural or tubular, should have screw holes every 90cm, which allow for greater versatility and relatively low costs.

3.5.1.3 Distribution of the shelving

The distance between shelves will depend on whether the documents are kept in boxes, or files stored on top of one another.

If documents are boxed, shelves can be 32cm apart, thus getting 7 shelves per bay, with the last shelf acting as a cover for the bay.

In order to make best use of the space, if documents are stored in files then shelves should be 30cm apart, making 6 shelves per bay, with the seventh acting as the cover.

The shelving ought to be secured to the floor, and braced at the back of each bay, especially in countries prone to seismic activity.

The distance between the floor and the first shelf should be 10cms to allow for ease of cleaning and free flow of air. The corridors between bays should be 70cm wide, and the main aisles between 1.00-1.25m. Corridors between bays allow for the free flow of air, for which reason shelving should not be secured to the walls. This also protects against the transmission of heat to the documents. It is very important that the distance between the shelving and the ceiling of the strongroom should be at least 50cms.

3.5.2 Shelving for particular types of paper documents

In order to store maps and plans which are generally large format documents needing to be kept in closed drawers on extended shelves with no cover or edge, a specific type of map storage needs to be used. The usual measurements for these drawers are: 100x70cms., which facilitates the storage of the average size plan (90x60cms).

Plans copied as heliographs, bond paper, plastics or whatever type of material, can be easily rolled and stored in PVC tubes, 10cm in diameter, covered with acid free paper and stored, preferably in boxes with vertical compartments.

Other important furniture in an archive building is mobile shelving. There are many systems available commercially, both manual and mechanically operated. These systems can be justified when there is a real lack of space, but cannot be justified on the grounds of low cost.

In order to work efficiently, an archive needs to have goods lifts and trolleys to enable documents to be moved safely, without being damaged.

3.5.3 Photographs, microfilms, magnetic tapes and audio visual material

When building a strongroom to house microfilm, it has to be remembered that microforms suffer deterioration due to the degradation of the film, particularly when this is cellulose acetate. Tapes produced since the 1970's have been made of polyester, which is a much more stable plastic, and does not suffer from rapid deterioration.

For this reason, strongrooms holding this type of material need to have air conditioning, or at least a small vault or strongroom in which the original films can be kept, and stored in acid free boxes. The temperature should be in the range of 19°C to 21°C, and with a relative humidity at between 45-55%. The environment should be free of contaminants.
Air conditioning systems are expensive, no matter the size of the strongroom. An alternative is to look for another storage site with better climatic controls, where the costs would be lower. The original films could be stored at this site, and copies at the archive building itself. Another possibility is to adapt refrigerators or industrial cold storage rooms.

3.5.4 Strongrooms for magnetic tapes

These need to be equipped with:

- air filtration systems to prevent the build up and distribution of dust
- climatic controls, with stable temperatures between 18°C and 21°C as this type of material is severely affected by sudden temperature changes
- shelving completely isolated from electromagnetic fields generated by electronic equipment, telephones, portable cassettes, microphones etc.

3.5.5 Strongrooms for audio visual material

Audiovisual material is very delicate and can degrade easily, due to a mixture of intrinsic factors caused by the process of developing, and extrinsic factors, chemical, physical and biological.

In the case of cine films, in which the carrier has a base of cellulose acetate, high temperatures accelerate degradation which happens when the acetic acid is released. When this acid is exposed to high temperature and humidity, it becomes reactive and causes the material to degrade rapidly. Climatic controls should be designed to allow for the periodic renewal of the air. Films in good condition should be stored separately to avoid the possibility of contact with acetic acid.

However, films produced since the 1970's have a polyester base and do not suffer from such rapid degeneration. Colour films require climatic control at lower temperatures.

As ultraviolet light affects all types of film, light filtration systems should be used.

3.5.6 Strongrooms for compact discs

These require specific conditions, such as:

- Even temperatures between 10°C and 20°C
- Relative humidity between 30-50%
- Storage in protective plastic cases, to prolong their period of use
- Periodic and thorough copying of their contents

3.6 Climatic Conditions In The Strongrooms

The general recommendation for temperature and relative humidity levels in strongrooms, regardless of the type of material being stored, is that they remain stable and avoid fluctuations.

In order to achieve this, the levels should be:

- Temperature at a range of between15°C and 22°C
- Maximum relative humidity of 55%

Recommendations for material stored in new methods of support are:

TYPE OF MATERIAL	TEMPERATURE		RELATIVE HUMIDITY	
	minimum	maximum	minimum	maximum
Compact discs	10°C	21°C	40%	55%
Magnetic tapes	4°C	16°C	40%	60%
Electronic documents	5°	32°C	20%	80%
Black and white film		<20°C		30%
Colour film		2°C		30%
Photographs	15°C	25°C	30%	50%

Chapter 4 Protective Measures

4.1 INTRODUCTION

Archive buildings, the documents stored in them and the personnel working there, need to be protected against all types of attack, whether from natural or man made, whether intentional or not. In order to achieve maximum protection, routines need to be established to protect the building, the documents and the personnel.

A general strategy needs to be established which will set out how the safety and stability of the archive, its documents, staff and visitors will be guaranteed. An inter-disciplinary team consisting of archivists, conservators, architects, biologists, physical chemists and mechanical engineers will manage this strategy. These teams will be composed differently depending on whether the building is new, a conversion or whether it shares a building with other services.

In every case, a security copy of this plan should be kept off site.

It is important that all conservation strategies have legal force, i.e. that they are expressed as being obligatory, perhaps incorporated in the internal regulations. All strategies should have short, medium and long-term plans for allowing maximum protection of the archive.

This chapter will discuss various risks and the methods of dealing with them.

4.2 NATURAL FACTORS

Even if they fully comply with all the conditions laid out in Chapter II, archive buildings are always subject to attacks from nature. Decomposition of material can be impeded and attempts should be made in all cases to maintain, as far as possible, constant levels of temperature and relative humidity and to avoid sudden changes in either of these variables, which is one of the fundamental causes of deterioration in documents. Those which have most bearing on archival buildings are given below.

4.2.1 Natural light and ultraviolet rays

Illumination is one important aspect of any architectural plan, and many architects like to use as much natural light as possible in their buildings, both for the effects it produces, because of the colours it creates, and the psychological effects it has on the workers and users, as well as being economical in the use of energy. Yet despite this, natural light needs to be used with caution, especially in the tropics where the light radiation is more intense and the dangers are thus greater.

The basic constituents of archival documents (paper, inks, leather, photographic material, films and magnetic tapes) are greatly affected by light. The damage suffered depends on the type of material, its capacity for absorption and sensitivity to light and radiation (see Appendix B), as well as the length and intensity of exposure, but it should always be remembered that the effects of radiation are cumulative.

4.2.1.1 Ways of dealing with the harmful effects of light

- Cover windows and lightbulbs of fluorescent lamps with film to block or reduce ultraviolet rays. The standard limit for ultraviolet rays in order to avoid damage to documents is 75µw/l. Any light emission higher than this ought to be filtered.
- Use curtains and other covers to impede direct light damage.
- Place perpendicular shelving at the windows in such a way as to avoid rays falling directly on them.
- Install a lighting system which is sectorized and controlled, which switches off lights after a predetermined time, to avoid unnecessary exposure to light rays.
- Avoid the use of mercury or sodium vapour lamps in the interior of the building, as these emit intense ultraviolet rays.

4.2.2 Temperature and relative air humidity

Temperature and relative humidity are interrelated. Relative air humidity is defined as the maximum quantity of water vapour in a determined volume of air which can contain a determined temperature. This means that the higher the temperature, the higher the quantity of water vapour contained in the air.

The general agreement is that temperature for storing paper documents should be between 15°C and 22°C and the relative humidity between 45-60% and it should be noted that:

- relative humidity higher than 65% will encourage microbiological attacks and physical/chemical degradation
- relative humidity below 45% will cause papers, leathers and parchments to lose, irreversibly, their structural humidity
- photographic documents, especially negatives, nitrate film and cellulose acetate, need much lower levels, between 5 and 20°C, and a relative humidity of between 45-50%.

Preventative measures taken in an archive to preserve documents ought to aim to guarantee stable temperature and relative humidity at the above levels. In this way, even if not kept in ideal conditions, material will not be subject at least to variations in temperature and humidity, which are some of the greatest threats to the preservation of the documents.

4.2.2.1 Methods of control

It is recommended that:

- a study is completed in advance, of the climatic conditions in the zone and variations are permanently monitored;
- the building be continually monitored in order to detect any pockets of stale air, as these will cause proliferation of insects and micro organisms;
- permanent system of ducted aeration and climatization be installed throughout the building;
- aeration and climatization systems be installed for every area of the building;
- when it proves impossible to maintain an uninterrupted climatization system, a combination of fans and dehumidifiers be used;
- aeration chambers are built to assist with the acclimatisation of documents and to avoid condensation and thermal impact;
- document treatment areas be built on the side of the building which receives least sun.
- materials used in the construction be absorbent and combined with architectural practices which promote air circulation;
- the objectives of the archives always be kept in mind, and solutions sought, within the means available;
- specific materials, such as films, discs etc. always be stored in strongrooms with the climatic controls relevant to the type of material being stored.

4.2.3 Vegetation

Trees which provide shade and grass or pasture land near the building will attenuate the effects of sun on the building. Nevertheless, these can also serve to attract birds, mammals and insects which can cause damage to the building and its contents.

4.2.3.1 Control of vegetation

To limit damage from the above, it is recommended that:

- trees not be planted near the building, and be at least 5 metres from walls and windows;
- gardens and grassy areas be situated at least 45cms from any building which houses collections;
- trees chosen should not have large leaves or deep roots;
- trees chosen should not be fruit trees;
- trees chosen should not use large quantities of water;
- grassy areas and trees be regularly inspected, to ensure that animal habitats are not being created;
- periodic fumigation should be undertaken;
- trees be regularly pruned and grass cut.

4.2.4 Fauna

In tropical, humid zones, it is usual to find a large variety of fauna which can affect the stability of the collections. These can be dealt with in the following manner:

4.2.4.1 Insects

The majority of insects which can infest collections in an archive are attracted by the basic materials, i.e. adhesives and paste in paper and bindings, as these are easily digested. Other insects attack cellulose (in paper and card, for example) and protein (in parchment and leather). The damage is not only caused because the insects eat the material, but also because they perforate it, burrow into it and leave bodily secretions on it. The presence of insects which might not cause any damage in themselves can serve to attract other insects, birds or animals which can present a threat, as well as others which will feed off the insects.

It is important to remember that insects do not feed on the collections alone. Buildings can provide a huge range of food for insects: the most obvious attractant are the foodstuffs left behind by humans, and that stored in offices and kitchens.

4.2.4.2 Mammals

Rodents are responsible for the loss of a large number of important collections, as they will gnaw paper, card, leather, skins, and adhesive bindings for food or to build their nests. Their droppings can cause chemical damage to the material, and they can gnaw through electrical cables and thereby cause fires.. They can cause damage in a very short time, as opposed to insects and micro-organisms. The accumulation of rubbish and food, and a lack of hygiene cause them to proliferate. They prefer warm, humid, and dark places. They can enter buildings through doors, windows and floors.

As well as threatening the collections, some rodents can carry diseases fatal to man, such as leptospirosos, bubonic plague, typhoid fever and rabies.

Other rodents, like rabbits and badgers, build tunnels and burrows around the building, which can cause damage to the foundations, pipe work and materials.

4.2.4.3 Birds

Birds are common in tropical climates. They can be found in roofs and inside older buildings, such as those where parish collections are found. The excrement of these birds stains the documents and causes chemical damage, while creating an ideal habitat for micro-organisms and insects (Annex B)

4.2.5 Control of fauna

The control of fauna requires constant vigilance in both external and internal areas of the building and the surrounding buildings and trees. Therefore, it is recommended that:

- all parts of the building are regularly cleaned;
- all shelving and documents are regularly inspected in order to detect insects or situations which could encourage them;
- the cafeteria is sited in a controlled area of the building, preferably outside;
- the eating of food is prohibited in parts of the building and restricted to a specific area, preferably outside;
- insecticides such as pyrethrum be regularly applied to floors, skirting boards, and access to sewage disposal conduits, *but never to documents;*
- archive buildings be constructed on pillars to allow inspections, diminish excessive humidity and the possibility of infections;
- walls, skirting boards, floors and ceilings be regularly inspected to detect the beginnings of infections;
- where underground infestation of termites is suspected, these only be dealt with by specialist firms;
- threats can be combatted through vigilance, as well as methods which use atmospheres lacking oxygen;
- doors, windows and ventilators be kept closed as much as possible, or covered with cloth or net, in order to prevent animals getting in;
- buildings be well maintained, as cracks or fissures in the building offer another means of intrusion;

- once detected, rodents be dealt with by traps, but it is better to employ a specialist firm to deal with such infestations;
- buildings which have a courtyard be fitted with specialist nets to prevent the entry of birds and other animals.

4.2.6 Micro-organisms

The micro-organisms which cause deterioration in the materials in an archive are bacteria and fungus. These excrete enzymes which break down organic material in to small amounts which form the nutrients appropriate for their metabolism. Such material includes cellulose, paper size, as well as starches, gums, gelatine and the leather bindings.

Some of these enzymes cause the cellulose to hydrate, which is usually accompanied by oxidizing decomposition, owing to the presence of hydrogen peroxide which many bacteria and fungus produce. The acidic products in the metabolism excreted by certain micro organisms can cause a serious acidic hydrolysis in the cellulose.

The result of enzyme activity is to change and irreversibly destabilise the material. At the same time, they produce substances which can stain paper, tissue, parchment or leather, particularly those coloured red, purple, yellow, brown or black.

The predominant factor in the increase of micro organisms is humidity present in the air. The types of fungus and bacteria which most frequently attack archival materials, works of art on paper, photographs, negatives and other paper documents multiply and increase when the relative humidity approaches or exceeds 70% and is at that level for a prolonged period. However some types of fungus increase at a lower level.

High temperatures, poor air circulation, shortage of light and the accumulation of dust help to accelerate the increase in micro-organisms once they have become established, but only relatively high and continuous humidity can initiate and maintain an increase. If the relative humidity falls below 70% and the materials lose their high humidity content, the micro-organism ceases to grow or becomes latent, but the spores remain in the substrate. These reactivate and grow when humidity levels increase.

Micro-organisms of all types can affect films, magnetic tapes, discs and diskettes.

4.2.6.1 Fungus

Fungus is not harmful as spores, as they are inert. Whenever conditions are favourable they will grow. Ideal conditions for the growth of fungus are temperatures which oscillate between 22°C and 30°C and a relative humidity of above 70%.

Attacks on archival material by different species of fungi can be identified during growth, as they take on different colours, dependant on the type. They can form mould and spores in large quantities can look like soot.

4.2.6.2 Bacteria

The ideal conditions for the growth of micro-organisms are temperatures in excess of 20°C to 37°C and relative humidity in excess of 70%. Humidity is essential for the growth of all micro-organisms, especially fungi. An environment with a high level of humidity will favour their growth and multiplication.

Stains caused by bacteria are different from those caused by fungus. The former are more compact and differently coloured, both at the outset and in the final stages, as when the material is in a state of decomposition they turn dark brown.

4.2.6.3 Methods of control

It is recommended that:

- there is ventilation and intense aeration, whether naturally or mechanically;
- in low, dark areas the temperatures be increased to create movement of air;
- when an infestation is discovered, specialists be called in to deal with it.

4.2.7 Floods

Floods are usually be caused by rivers bursting their banks on a plain, by the sea breaking coastal defences and by flash floods. The latter can be caused by adverse weather, or by accidents such as burst pipes. Floods can also be caused when attempting to extinguish fires.

The damage caused by flood water is particularly severe when documents are stored in basements or other areas where the water can accumulate at high levels and be difficult to disperse. Floods can cause severe damage because documents cannot be dried rapidly and above all, because the atmosphere is warm.

In tropical climates, the growth of fungi in areas affected by flood can appear in approximately 48 hours. Depending on the type of paper and ink used, the outcome can be that the pages stick together and the ink runs, and thus the documents become illegible. When they begin to dry out, they become distorted and form a compact mass which often is beyond saving.

4.2.7.1 Methods of prevention and protection

The best method of protection against river and sea flooding is to:

- site buildings in the highest area possible;
- avoid sites at the bottom of a hillside;
- incorporate specific protective methods to allow resistance to floods;
- install anchor points for the construction in the foundations and protection against landslides and lateral movement;
- install additional land drainage;
- avoid storing collections in basement areas;
- construct canals or valves to obstruct the free flow of flood water or sewage;
- ensure that ceilings and floors are built of an easy cleanable material;
- ensure that all electrical connexions are fitted with a circuit breaker.

4.2.8 Earthquakes

Earthquakes, which are caused by oscillation of the earth on 3 axes simultaneously, can frequently cause the total destruction of buildings and all their contents. The damage they cause is mechanical. During an earthquake structures collapse due to 4 principal factors: tremors, the rupture and opening of fissures in the earth and walls, the uneven surfaces created in the areas affected by the fissures and liquefaction caused when the ground becomes semi-liquefied. The twisting of the structure leads to damage to the installations, for example short-circuiting and breaking of the hydraulic piping, clean water and residues.

A tremor of the magnitude 4.0-5.0 on the Richter scale will not cause great damage, but anything above 5.1 puts the building and its inhabitants at risk. An earthquake of the magnitude of 7.0 can cause destruction of buildings, bridges, railway lines and open great fissures in the earth and cause serious landslides. Such events can also engender fires and floods.

4.2.8.1 Protective measures

In areas subject to such disasters, archival buildings should be equipped with anti-seismic measures, and the shelving should be suitable to minimise or reduce, as much as possible, damage to the documents.

The methods of protection against earthquakes include the building of lateral slopes, with columns fixed to support the lateral loading, as well as raised columns and mooring ropes in the bracing bars of the units, which help the installation to lean and stabilize.

Shelving which is the most likely to collapse or bend due to any earth tremors, should be fixed to the walls in order to avoid continuous blows, collapse or the danger of tilting.

Electrical installations and lighting can also be affected and need to be fixed to the ceiling, angled in an appropriate way, and equipped with a secondary independent system fixed to their respective niches in the building structure.

Hydraulic and sanitary piping could also be broken because of the tremors and occasional flooding could be caused.

4.2.9 Hurricanes and storms

Hurricanes are formed from simple whirlpools in the tropical seas, which, when formed, increase to cover areas up to one thousand metres in diameter. They can move at between 40-64 km per hour, but can remain stationary, change direction and diverge with speeds reaching almost 96.5 km per hour. The winds have speeds in excess of 320 km per hour, the rampages are almost constant and the rain is strong, but of short duration, and hailstones also feature in such storms. When they reach land they cause powerful waves which destroy everything in their paths.

This type of phenomenon, as well as causing physical damage to the buildings, can cause floods, the consequences of which have already been described.

4.2.9.1 Protective measures

Protection of buildings from the effects of hurricanes and storms should include:

- construction of the building of materials resistant to strong winds;
- installation of climatisation equipment in the ground, on the floor but not in the ceiling;
- provision of sloping roofs fitted with good drainage made of material resistant to the pressures caused by strong winds, and preferably not constructed of wooden beams;
- limiting the number and size of windows;
- installation of systems of protection against lightning;
- installation of fire detection and suppression systems;
- adaptation of appropriate electrical, sanitary and hydraulic connections.

4.3 MAN MADE DAMAGE

In the course of his daily activities, man can cause much damage to archival buildings, their contents and their users. The greatest dangers come from the following factors.

4.3.1 Contamination

The air is composed of oxygen, nitrogen, carbon dioxide and hydrogen, all of which lead to combustion, fermentation, oxidisation and hydrolysis in materials. Contamination agents are both external and internal.

4.3.1.1 External contaminants

- *air:* the air in urban and industrial areas contains a huge range of particles and gases. Particles are composed of microscopic parts of contaminants, mainly of dust soot and micro-organisms.
- *dioxide:* this is in the atmosphere principally due to the burning of fossil fuels used by industry and by cars. When combined with oxygen it becomes sulphur dioxide. This chemical reaction is catalysed in the form of small metallic particles. The combination of sulphur trioxide and water, whether from the air or from paper, forms sulphuric acid, which causes hydrolysis of the cellulose.
- *ozone*: this is a powerful oxidising agent. In industry it is used as a sterilising bleaching agent. In high concentrations it is highly toxic and has a characteristic smell, easily noticeable near electrostatic copiers, which produce this gas.
- *nitrogen dioxide*: car exhausts produce a large part of this gas found in the air. The water-soluble oxides (dioxide and monoxide) create nitric acid, which acts in a manner similar to sulphuric acid.
- *hydrogen sulphate:* this has a characteristic smell, that of rotten eggs, and is generally produced by the bio-degradation of proteins which contain sulphur. As it is a weak acid, it does not cause significant damage to organic materials; however, it can seriously affect metals, especially silver, and thus is a danger to photographs and silver plate films.
- *salt* present in the air in coastal areas is made worse by strong winds. As salt is highly hygroscopic, it poses an additional threat to documents in humid environments.
- *dust*: the air contains numerous particles which can affect ducts, windows and aeration channels, and obviously the documents and the personnel who work in an archive. Dust also contains particles of crystalline and amorphous chemical substances, such as earth, sand, soot and a huge variety of micro-organisms, as well as residual acids and gases from combustion and industrial activities.

- Dust does not only affect documents aesthetically. When one considers the dirt retained in paper, from insect excrement or incrustations from wax, glues and dust from various origins, the destructive nature of dust has to be recognised. Small particles of minerals can be abrasive and sharp. Dust does not only stick to the surface of documents, but also can attack the interstices and become absorbed in the chemical composition of the document.
- Another relevant consideration is the hygroscopic content of dust. When there is high relative humidity, water and acidic contaminants can be absorbed. What happens is that the chemical constituents of dust act as a catalyst to convert the contaminants present in the air chemically, and thus form substances which can cause degradation of cellulose. Micro-organisms and their spores, present in dust, adhere to organic material and thus, finding conditions suitable for growth, proliferate and cause chemical change and degradation.

4.3.1.1.1.1 Control of dust

- Dust can be reduced inside repositories by keeping windows closed and using filters or curtains.
- Documents and conservation areas should be dusted on a weekly basis.
- A thorough cleaning, using vacuum cleaners should be undertaken weekly.
- Floors and walls should be cleaned using a damp solution based on ammonia and bleach.

4.3.1.2 Internal contaminants

Within archival buildings or libraries, there are various services which use machines and chemicals which can cause gases and vapours harmful to people and documents. In the fumigation of documents in general, toxic gases containing sulphur and other compound oxidants. Other contaminants can come from paints and cleaning products which contain petroleum derivatives.

The process of microfilming causes ammonium gas to be released. Photographic laboratories use chemicals including sulphurous substances when fixing. Electrostatic copiers use solvents and release a considerable amount of ozone vapours. The best solution is that these vapours are extracted and released outside the building. This should also happen in smoking areas. Often, however, chemical residues are released and this is made worse where there is an air conditioning system, as contaminated air is thus re-circulated.

When planning the building and its shelving, architects should take into consideration the problems of contaminants being released, as well as the acoustics, durability, stability of climatic conditions and the aesthetic quality. Contaminants can come from materials in common use, such as varnishes, woods, adhesives, and carpets amongst others. Many of the chemicals which affect people are also harmful to documents: one of the most dangerous is formaldehyde.

This is a colourless gas with a perceptible smell in a concentration of approximately 1ppm. At levels of 0.05 to 0.5ppm it can cause eye irritation, and at 1ppm, irritation of the nose, throat and bronchial tubes. 1ppm is the acceptable level to be used when working in closed areas, without damage to health. Formaldehyde is always present in the air.

It can affect collections in two ways. When humidity is a factor, even at very low levels of relative humidity, formic acid will be formed. Studies show that emissions increase at high levels of humidity and temperature.

Paints with a latex base and acrylics are generally safe, but nothing really acts as a barrier against formaldehyde emissions. Oil based paints, when drying, cause the release of volatile organic materials. These compounds can be extremely corrosive and should be avoided.

Metal shelving is generally covered with a protective coating of enamel. If this has not been properly treated, then high levels of formaldehyde can be emitted. Metallic shelving of preservation quality uses an acrylic resin treated and modified with a catalysed melamine. Another alternative is to use a fine covering of powder, which eliminates all volatile emissions. A coating of powder consisting of a hybrid of heat-treated epoxy-polyester resin is used and the makers guarantee that this covering is inert.

4.3.1.2.1 Methods of control

- Avoid using materials which are sources of formaldehyde inside the building. These include carpets, chipboard, wood composites, laminates, glass fibres, inks and plastics.

- Ventilation and the use of absorbents material such as plaster, carbon or calcium carbonate can reduce the formaldehyde content by half, but should not be used as a permanent measure.
- The use of polyurethane and polyester as coverings can control formaldehyde emissions. However, it is recommended that anti-humidity polyurethane should be used, i.e. that in which polymerisation occurs when contact is made with atmospheric humidity, thus forming resistant finishes.
- Use resins of a latex type in the interior of the building. These generate less corrosive sub-products and produce fewer fumes.

4.3.2 Armed conflict

These situations can result in massive loss of buildings and human life and archive collections can be affected, although they may not be a front line target.

4.3.2.1 Methods of protection against armed conflict

In order to minimize risks associated with such situations, it is recommended that:

- archive buildings are situated at a distance from military installations, or areas which could be considered war zones;
- additional structural protection for buildings be considered, at least for the storage areas;
- any documents stored on higher floors be moved to lower ones;
- at the outset of the conflict, the exterior security of the building be reinforced, by means of steel security barriers or iron bars at the windows, sandbags etc.;
- the capacity for fighting fires or any other conflagration caused by war damage is increased;
- the building be equipped with electricity generators and additional water tanks;
- the windows and skylights be protected by means of nets or curtains.

4.3.3 Theft or vandalism

Such actions are difficult to predict and happen frequently. They happen because it is inherent in human nature and is leading to the total or partial disappearance of the historical patrimony.

4.3.3.1 Methods of prevention and control

To prevent such actions, it is recommended that:

- the building, access points, strongrooms and workrooms are under permanent vigilance, whether by means of security personnel, or by electronic means;
- all entrance points be controlled, and, if possible restricted to set hours;
- all staff are fully trained and made aware of the threat, so that they will be vigilant and immediately aware of any theft or act of vandalism.

4.3.4 Fire

Fire is one of the greatest threats to an archive and its collections. Because of their cellulose base, once burned they are irrecoverable. Those documents which are not destroyed by fire are affected by being scorched, are covered by soot, become friable, and are affected by smell, smoke etc. For centuries fire has been the great enemy of archives and other such buildings which are constructed in and also contain large quantities of combustible material.

Fire is a chemical reaction which happens when a combustible material is mixed with oxygen and heats up to the point where flammable vapours are produced. These vapours, when they make contact with anything sufficiently hot, are then ignited and flames are produced.

Fire also brings a second dangerous element, i.e. the water which is usually used to suppress it. This causes direct damage to the documents, such as swelling of the fibres, fragility, wrinkling, increased solubility etc. and the growth and spread of mould and other biological agents.

Generally fires are caused by carelessness, lack of vigilance and lack of maintenance. The most frequent causes are lit cigarettes, sunrays, lightning bolts and faulty electrical connections.

If the building is structurally sound, it is likely that the flames will consume all combustible material in the storage areas and then diminish. However, if the structure is not sufficiently fire proof, and the building materials are themselves combustible, then the fire will spread to adjoining spaces and the process will continue until the entire building and its contents are destroyed.

4.3.4.1 Preventive measures

Given that fire always originates when all the elements are in place to allow it to happen, efforts to avoid this should be directed towards:

- avoiding the accumulation of builders rubbish, shelving, combustible material, woods, paints and cotton materials;
- keeping areas surrounding the building free of rubbish;
- using fireproof materials in the construction of the building;
- constructing fireproof walls and points of access;
- equipping all access and exit points with fireproof doors;
- equipping the site with mobile shelving, treated with antioxidants;
- ensuring that all electrical, sanitary and hydraulic equipments is technically up to date, and durable;
- installing fire detection and suppression systems, both automatic and manual;
- designing and publicising the plan for evacuation of the building;
- forming groups of voluntary fire-fighters form amongst the staff;
- distributing protective equipment for those involved in fire fighting.

4.3.5 Natural wear and tear of the building

The building also requires a maintenance plan, both short and long term, in order to avoid damage caused through material fatigue, accumulation of contaminants, cracks appearing in the walls and ceilings, humidity, pipes breaking, drains blocking, defective electrical cables etc.

4.3.5.1 Preventative measures

Any maintenance plan should include the following elements:-

- Regular inspection of the building as follows:
  - daily for general repairs and maintenance
  - weekly for environmental control methods and electrical circuits
  - fortnightly for water and sewage pipes
  - monthly for general cleanliness and hygiene, in order to detect any dirt present, the levels of pollution and the presence of micro-organisms.
  - quarterly for fire detection and suppression systems
  - annually for the building materials, entrance/exit points, foundations, insulation and impermeability.
- Regular reading of the temperature and humidity levels
- Programme of regularly turning on lights in the strongrooms, to avoid long period of darkness
- Regular programmes of fumigation and rodent control
- Constant checking of electrical, sanitary and hydraulic installations, windows, doors, floors and water drainage pipes and replacing when necessary
- Regular cleaning of air and ventilation ducts
- Regular intensive cleaning of floors, walls, windows and doors and use of a high power vacuum cleaner to eliminate pockets of dust.

4.4 PERSONNEL

Personnel as well as documents should be taken into consideration when drawing up an evacuation plan made necessary by any of the above-mentioned factors.

4.4.1 Evacuation plan

Below there follows a proposal for an evacuation plan which can be adopted by all archive buildings.

1. Conduct a risk analysis by establishing with the authorities all types of risk which might threaten the building and its activities now and in the future
2. Create a group of personnel, comprising representatives from each sector who would be responsible for identifying potential areas of risk which could lead to a disaster, whether at the present or in the future.
3. Draw up evacuation routes to appropriate to the risk or disaster.
4. Appoint people in each area to be responsible for directing the evacuation of that area.

5. Establish assembly points for when the building has been evacuated.
6. List the emergency services and auxiliaries.
7. List those services which can provide logistical support.
8. List those personnel responsible for internal and external communication.
9. Hold evacuation and disaster practices.
10. Have clear signage throughout the building on all doors, stairs, windows, emergency exits and escape routes.
11. Prioritise which collections should be saved, in order of importance, and make arrangements for their future storage.

ANNEXES

Annex 1 Tropical Zones

There are different tropical zones which can be described as follows:

- The *equatorial humid zone* characterized by high temperatures between 26-27° C all year round, with little variation between the day and the night. In the afternoons there are often heavy downpours of rain, for short periods. The relative humidity of the air is always very high. In humid equatorial zones near the sea, fierce storms are constant and certain regions are more susceptible to thunderstorms, tornadoes, typhoons and hurricanes.
- The *tropical humid zone* is similar to the equatorial humid zone in its high temperature and relative humidity all year round. However there are two seasons: winter with more prolonged rain and summer with more intense heat and storms. In general these regions are near the sea. The oscillations in temperature and relative humidity are more perceptible over short periods of time, and lower temperatures are more noticeable during the night.
- The *sabana tropical zone* in which there are two distinct seasons, the hot and dry winter and the warm and humid summer. Because of their distance from the equator, these zones have the most prolonged dry spells. Solar radiation is very intense.
- *Desert and arid zones:* these are regions with high summer temperatures and cold winter nights. The relative humidity is always below 50%.
- *Subtropical zones:* different regions have different weather conditions. In winter it is possible to have cold temperatures and in summer for them to be high, similar to tropical climates.

Annex 2 The Media

A.2.1 Paper

Paper is a material composed principally of cellulose fibres derived from cotton, linen, hemp or wood pulp. It contains many additives such as sealing agents, fillings, coverings and pigments. The composition of paper seriously affects its physical properties and its likelihood to deteriorate.

Although its principal structure corresponds to that of cellulose, its other components modify its chemical and physical behaviour. The physical structure of these materials determines to a large extent its tendency to deteriorate and the processes which lead to colour change and mechanical resistance. For that reason it is necessary to know the separate components of paper.

A.2.1.1 Cellulose

This is a polysaccharide formed by units of d-glucose, which fuse together through links of B-beta(1-4). It has numerous qualities, amongst which is insolubility in water and being subject to oxidisation that allows the paper to age and determines its solubility in alkalis. Its physical properties, such as mechanical resistance (or resistance to traction), are determined fundamentally by the grade of polymerisation.

In multiple X-ray studies cellulose has been shown to contain well-ordered and compact crystalline areas and amorphous, less well-ordered areas. It is in these latter where water, other solvents and chemicals which cause deterioration can most easily penetrate and cause the fibres to swell, chemical reactions to occur and even the dissolution of the cellulose. Thus the greater the crystalline ratio in the cellulose of a fibre, the more insoluble the material will be and less likely to suffer from chemical or biological deterioration. Linen papers are most resistant because the types of cellulose they contain have more than 90% crystalline areas whereas cotton papers have only 60%.

A.2.1.2 Sizing

These are substances which are added to the pulp or superficially when the sheets are formed and whose functions are to:

- enable the retention of fibres, fillings, and certain colour materials;
- prevent ink running;
- make paper resistant to humidity;
- make the leaves solid and long-lasting.

Older hand made papers had superficial animal size applied. The most common was resin applied generally and mixed with aluminium sulphate which facilitated the coating of the fibres with the size. Today synthetic resins are used to make paper resistant and permeable in humid and dry conditions and these present least problems.

A.2.1.3 Fillings

Mineral substances (kaolin, talcum, plaster, calcium carbonate, barium sulphate amongst others) are added to pulp to increase the weight of the paper and create homogenous surfaces to fill in the space between the fibres. They improve receptivity to ink, respond least to atmospheric changes, give a white colour to the sheets, offer the best resistance to wear and tear and can improve characteristics necessary for printing.

A.2.1.4 Cloth paper

Papermaking had its origins in China in the 1st century AD, but remained secret until the beginning of the 8th century AD when Chinese prisoners in Samarkand passed on the method of making it to the Arabs. In the same century papermaking was established in Baghdad.

Due to the expansion of the Arab Empire, paper making was introduced to Spain during the 11th century, and the first paper mill established in Játiva, Italy in the 12th century AD. In the following centuries it was in common use throughout Europe for documents, drawings, paintings, engravings and later in the printing of books.

For more than 6 centuries the principal materials used in paper manufacture were open fabrics such as linen and cotton cloth. The fibres are considered of high quality because they contain almost pure cellulose and its density guarantees that the paper will be resistant and allow for the creation and interweaving of the numerous chains of hydrogen. The process begins when the fabrics are shredded, are mixed together to ferment and are later mixed with clean water and crushed by hammers in order to obtain a fine pulp. Cellulose pulp, dissolved in water, is put in tubs and with the aid of a frame, sheets of paper are made manually. They are then pressed and dried. Finally an animal based adhesive is applied as size which gives them greater resistance and avoids the ink expanding when writing is added.

From the 18th century onwards there was an increasing demand for paper, which meant that the methods of making it had to be modified. In the first half of the century a Dutch stamping trough was introduced in Europe, which replaced the older hammers and meant that production could be increased, although at the same time this shortened the paper fibres and thus lessened their resistance.

A.2.1.5 Acidic paper

With the growth in demand for paper, primary materials became scarce, so that by the 18th century, other vegetable fibres were being investigated. Yet it was not until the middle of the 19th century that the method of obtaining cellulose from wood fibres was developed.

Much different from cotton, a primary material with more than 93% cellulose, wood has a maximum cellulose content of 50%. In its makeup it contains elements such as hemi cellulose and lignin, which when oxidised produce compound chemicals of acidic characteristics of a yellowish colour. At the same time, the fibres from wood are much shorter, and thus do not offer the same possibility of interweaving. As a result the papers are less resistant.

The first papermaking machine was invented in France in 1799, by which paper was formed in system of wire mesh in continual motion. The production of machine-made papers enabled the glue to be added much faster than in the manual system when adhesives of animal origin were used, and thus introduced the system of sizing with aluminium sulphate-resin; the internal sizing is achieved through the addition of resin soap and aluminium sulphate to the paper paste during the refining process. Aluminium sulphate is the most important source of acid in this type of paper.

A.2.1.6 Alkaline papers

At the end of the last century, the paper industry reintroduced the use of calcium carbonate as a filling and introduced a new synthetic adhesive as a size, thus obtaining acid free papers, which guaranteed the preservation of documents. Alkaline boxes of different weights used for the storage and security of documents are produced in the same way.

A.2.2 PARCHMENT

Parchment is obtained through a process of curing sheep and goatskins; a fine parchment, called vellum is obtained from calfskin.

This material was used as a base for writing in Asia in ancient times. However, it was in the 2nd century BC that its manufacture was perfected in Pergamo, as a response to the difficulties of obtaining Egyptian papyrus. To begin with, parchment was rolled, similar to papyrus, but after the 4th century AD, it also began to be used in book or codex format.

Paper almost completely replaced parchment as a base for writing, though parchment continued to be used as a binding material for documents and books.

Parchment is very vulnerable to climatic factors. In conditions of high humidity it absorbs water until almost completely soaked. When humidity falls below 40% it quickly loses its humidity structural, with a resulting reddening of the collagen. At this point it loses its shape and flexibility and becomes brittle.Its chemical preservation is good as it has an alkaline reserve which protects it against corrosion from metallic inks and from acids present in the atmosphere as contaminants such as sulphur dioxide (SO2).

On the one hand, parchments are more resistant because of their alkalinity, but on the other they are vulnerable to climatic changes, because of their irregular structure, and can expand and contract though absorption or loss of water. Thus they are best preserved in an environment offering stable conditions.

A.2.3 LEATHER

Leather is cured animal skin. In ancient times it was used as a base for writing and latterly as a binding material. From the beginnings of the 19th century, skins were cured in an infusion of wood extracts, leaves, fruits or different vegetable type. These extracts, known as tannins, combined with proteins, modify the molecular structure and transform the skin into leather with excellent physical resistance.

Vegetable tannins were gradually replaced by synthetic chemical substances, which had the same properties but are much easier to use and obtain. These are obtained through the condensation of carbolic acid with formaldehyde and generally produce acids which accelerate the deterioration of the leathers.

The quickest method of curing is by using sulphuric acid. This is the most efficacious, although it does eliminate lime and makes the leather more vulnerable, allowing dye to be applied with anilines which offer a great variety of colours, increase production and reduces costs. However, the final result is of an inferior quality.

Chemical deterioration results from the reaction between the residue from the curing process and elements present in large quantities in the air, such as oxygen, gases and contaminants, specifically in industrial and urban areas, that can penetrate the leather via the humidity in the air. Recent leather shows more susceptibility to acid as it absorbs acid rain from the air and this causes changes in the colouration and causes damage to the fibrous structure, transforming it into a purple dust, called ‘purple deterioration’. This process can be seen in parts of books which have been exposed to the air, such as spines, while the covers, which have been protected by the shelving, are in better condition.

A.2.4 INKS

In general inks are made up of a colorant, an agglutinant which keeps it in suspension, and a vehicle to allow for its dispersion and fluidity. Its adherence to the material to which it is being applied is achieved in many cases through chemical reactions by means of *removedores*, these are generally acids, which interact with the pigment and the medium.

A.2.4.1 Carbon based inks

The oldest calligraphy inks known, which date from c 2,500 years BC, came from Egypt and China and were composed of lampblack mixed with fixing agents, such as gum arabic and fish glue. Its durability was due to the quality of the fundamental materials, especially the pigment. With some changes in its composition, this ink was taken to Europe and used almost exclusively until the 15^{th} century.

Archival quality Chinese ink which is used nowadays for documents for permanent preservation, is an adaptation of the original formula; its properties are the same and the black colour is permanent.

A.2.4.2 Metallo-acidic inks

The most used ink of this type is iron gall ink, which is composed of iron sulphate, gallotanic acid and a fixing agent, usually gum arabic dissolved in water. Galotanic acid is a tannin taken from a gall, which is to be found in the oak trees. The mixture of tannin with iron sulphate forms an iron tannate, which, when applied to paper, is of a weak colour. With the absorption of oxygen from the air, the iron tannate turns dark brown. For this reason, in order to facilitate writing, it was common to add colours to the mixture. This type of ink began to be used in the 15^{th} century.

The corrosion of paper, which can be seen in many documents written in iron gall ink, is intrinsically due to the basic components. Iron sulphate, upon oxidation catalyses the sulphur dioxide present in contaminated air, thus forming sulphur trioxide, which together with humidity, forms sulphuric acid. There are various studies which show that micro-organisms specifically attack these inks, causing chemical changes and accelerating their degradation.

Amongst other metallo-acidic inks, we must also consider those constituted of copper sulphate, coloured blue and green, used until last century for colouring or painting, and especially on maps. As with iron gall inks, these metallo-acidic inks cause acid damage to the paper produced by the reaction between oxygen, humidity and contaminants.

A.2.4.3 Modern calligraphic inks

Fluid inks for metal pens, which replaced iron gall inks retain some of their characteristics, such as the use of chemical solvents. The synthetic pigments are very sensitive to light, water and alkaline products, and amongst these the colour black presents the greatest resistance.

The modern ink known as china ink is an adaptation of the old formula, but with the same properties and is sold for use in fine drawing pens and for documents intended for permanent preservation.

Inks for fibre-tipped pens are composed of an aniline dissolved in water and alcohol and are characterized by their low resistance to light and water. However, they do not cause damage to paper.

Inks for ballpoint pens have an aniline base and use a synthetic viscose resin as a fixing agent, the function of which is to achieve a uniform distribution and rapid drying on the surface of the paper. In humid conditions, the paper absorbs it.

A.2.4.4 Printing inks

Printing inks can be classified as typographic, lithographic, or zincographic, offset and others, and have a varnish, generally linseed oil which has been substituted for synthetic resins, as an original fixing agent. Generally these inks are stable and harmless to paper.

Inks for stamps, nowadays made from synthetic pigments, can be permanent when of high quality, although some which are susceptible to water and light can be found.

Typewriter inks and carbon paper used to make copies usually have pigments with a base of black carbon, thus making them permanent.

Photocopier ink is composed of a pigment and a toner activated by heat. The black pigments in these inks are composed of lampblack and are this considered to be permanent. Any problems they present are caused by the fixing of the copy, which often depends on the concentrations of toner.

The formula for laser printer inks is based on lampblack or carbon, similar to that for photocopiers, and are thus considered equally permanent. Now inks for injection printers or for ink jet printers have an aniline base and do not offer resistance to water or light.

A.2.5 PHOTOGRAPHS

A.2.5.1 Paper photographs

In the 150 years during which images have been produced, a diversity of photographic processes have been invented. The majority of these consist of a laminate structure: a primary medium, a fixing agent and, in some cases, a secondary medium. The primary medium is the base on which the fixing agent is impregnated and in which there is a layer sensitive to light; the secondary medium is whatever accessory material to which a photograph can adhere. Photographs differ from other paper media because of their fragility and their complex chemical composition.

Amongst other materials used as media for photographs are metal (copper plate covered with silver for daguerrotypes, iron laminated for ferrotypes), glass (for ambrotypes, negatives, positives or diapositives), paper (for all types of positive and some of the first negatives in the 19th century); plastics (film negatives, acetate, nitrate, polyester etc). Today resin papers are found throughout archival collections. These have been covered on both sides by plastics to ease the processing and to avoid them curling.

The layer of fixing agent contains the material which forms the visual image. Throughout the history of photography the most common fixing agents have been albumen, colodion and gelatine. The stability of these fixing agents is essential to guarantee a fixed, unalterable image. During the 19th century, albumen was used predominantly for paper photographs, while in the last 100 years the use of gelatine has prevailed, both for positives and for negatives.

The part of the photograph which becomes the image consists of finely divided metallic particles, or in the case of colour photographs, colorants or pigments. The preservation of the photograph involves the preservation of these delicate particles in the image of the fixing agent and of the medium.

The principal causes of rapid deterioration in photographs are inadequate care, poor quality materials and inappropriate handling.

A.2.5.2 Films

Cine films, microfilms, negatives, transparencies or other photographic products made with a film base have the same conservation problems.

A film is composed of a base of transparent plastic, a much finer layer of gelatine emulsion and an image, either composed of colorants or, in the case of black and white images, of small silver particles.

The most serious damage can be caused by the deterioration of the plastic base of the film. The first base to be used was made from cellulose nitrate, which is very unstable and when it deteriorates, there is a high risk of combustion. Around 1930 specific types of cellulose acetate began to be produced which were not so inflammable. Even they are still extremely unstable as they deteriorate through dispersing acid acetate into the atmosphere; this is known as the ‘vinegar syndrome’. Finally, throughout the 1950’s the plastic base began to be made of polyester.

Polyester, known also as polyethylene tetralate or PET, is much more stable and thus is a successful substitute for cellulose acetate in almost all modern photographic processes.

A.2.6 DISCS

Discs which contain sound recordings are made with different types of plastic, which can be;

A.2.6.1 Acetate

In these discs the recordings were made instantly. From 1930, the majority were produced on an aluminium base, covered with a lacquer of cellulose nitrate and plasticized with castor oil.

Cellulose nitrate, with the passing of time, decomposes and reacts with the vapour in the air or with oxygen to produce acids that act as catalysts in other chemical reactions. These reactions are accelerated in high temperatures and high relative humidity. The plastic covering is gradually lost, the disc becomes brittle and the recorded information is irreversibly lost.

A.2.6.2 Shellac

The first shellac discs date from 1890 and this process was used until 1950; they are relatively stable, but in high relative humidity, they become brittle. After every reproduction a fine dust is dispersed, the grooves get worn out and all the information is lost. Shellac is resistant to attack from fungi, but other organic materials which are added during the manufacture of the discs are not.

A.2.6.3 Vinyl

Vinyl began to be used from 1950. It has been proved to be the most stable medium of all those used in the making of discs. The lifetime of vinyl has yet to be defined. When exposed to ultraviolet light or thermal variations, the chloride of the vinyl decomposes chemically, causing accumulated and irreversible damage.

For all types of disc, risk of abrasion or obstruction of the grooves should be avoided.

A.2.7 MAGNETIC MEDIA

Magnetic tapes have been in use since the end of the Second World War. They consist of a medium and a fine layer of agglutinant which acts to retain the iron magnetic particles which store the engraved information. This information can be either audio or video.

Between 1935 and the 1960's, the medium was made of cellulose acetate, a material with little resistance and susceptible to deforming. They then began to be made of polyester, a chemically stable material. In advanced states of decomposition, the magnetic tape becomes brittle and easily breaks when folded or stretched.

The most common agglutinate used today is polyester polyurethane and the most common particle is ferrous oxide gamma. If the agglutinate loses or changes its integrity, the tape is wiped and becomes brittle, making reproduction and recovery impossible. Any alteration in the magnetic properties of the pigment means that the signals engraved on the tape will be irretrievably lost.

A.2.8 ELECTRONIC MEDIA

A.2.8.1 Compact discs (CD and DVD)

Originally compact discs (CD) were developed to record music (digital compact audio disc CD-DA) as a replacement for vinyl, but later began to be used to record data (CR-ROM- Compact disc read only memory) or videos (Digital video Disc-DVD).

These discs are made by 4 layers of different materials: a polycarbonate base, on which the cavities which contain the digitised information are fixed; a fine layer of aluminium to cover the cavities, a layer of lacquer which covers the aluminium and finally one of ink to enable labelling.

Although the long-term stability of these is still unknown, much depends on the quality of the materials used in their manufacture, and how each layer will age and interact with the other layers.

The conservation of electronic media will, in the long term, be subject to rapid changes in the technology of recording and reproduction. Thus it is necessary to keep abreast of all variations and make alterations necessary to avoid machinery and programmes to read and interpret the discs becoming obsolete.

Annex 3 Factors Which Affect Paper

As paper is the medium most frequently used in archives, especially historical archives, this annex will contain more information on those factors which can affect paper deterioration.

A.3.1 Intrinsic factors

A.3.1.1 Acidity

In the process of chemical degradation, the factor which contributes most to paper becoming brittle is the decomposition of the cellulose in acidic conditions. It is estimated that acid deterioration affects between 80-90% of archival material. This is made worse by conditions of high temperature and relative humidity.

The acid impurities such as chloride products used to whiten paper, aluminium sulphate and glue, as well as the lignins of wood pulp, produce acid in paper, altering the cellulose and other components.

The most important source of acid is aluminium sulphate used in the internal size of some papers. In a water solution, the aluminium sulphate ionises as a salt with a weak base and strong acid, the resulting solution is acid and as a result of this hydrolosis, the PH fluctuates between 2 and 5.

Another significant source of acid is lignin, found especially in machine made papers or in those which have used pulp of high quality. It is a complex organic polymer which easily oxidises and, as a result produces, acidic products and decolorants.

The carboxyl group, which forms as a product of the oxidisation of cellulose, is another source of acid. Oxidisation is heavily influenced and accelerated by catalysts such as iron and copper ions, which can come from the recipients and from metal machinery used in the manufacture of paper pulp, or from the water used during the manufacturing process.

Acids can also affect leather bindings. Any internal acidity has usually been caused by agents used in the curing process. In the presence of iron or other transitory or heavy elements in the leather such as dust, curing agents, corrosive colours, pigments and others, sulphur dioxide absorbed from the atmosphere oxidises rapidly to become sulphur trioxide and forms sulphuric acid when mixed with humidity. Acidic hydrolysis causes leather to be reduced to dust, at the same time as converting the vegetable tannins to a brick colour

A.3.1.2 Decomposition of inks

The decomposition of inks is caused by a complex superimposition of different processes: the natural ageing of the paper unites with the composition and its capacity to create chemical reactions in the medium. Environmental and storage conditions are very influential here, especially temperature and relative humidity, as well as preparations and inorganic fillings which can affect the medium.

The inks which cause damage to paper are iron gall inks or those made from various transitory metallic ions. The first signs are a discolouration of the medium and, in the area immediately surrounding, the ink has a brown stain and is particularly visible where broad strokes of pen or brush have been used. This spreads throughout the medium and often can be found to have spread to pages underneath. Finally, the deterioration is so severe that it covers entire areas, especially around lines on which there is writing, thus losing information. The medium finally becomes impossible to use.

Iron gall inks are made up of 4 primary ingredients; tannin, vitriol (iron sulphate), water and gum arabic. Despite the fact that these ingredients have been used continuously, the ratio in which they were used and the contaminants which they contain have varied though time, and thus their preservation and treatment of the collections which use this ink is very complicated.

Studies have shown that iron sulphate has a high concentration of iron ions, which accelerate oxidative reactions in the components of paper.

The high acidity of the majority of metallo-acidic inks is caused by the presence of groups of sulphates and acids which are used during the making of ink. These hydrolyse the molecules of glucose, thus causing the physical degradation of the cellulose. Both oxidisation and hydrolysis react and reciprocate the reaction one with another.

A.3.1.3 Brittleness

From the 18th century onwards, there was an increasing demand for paper, which meant it was necessary to modify the means of production. In the first half of the century the Dutch stamping trough was introduced into Europe as a replacement for the old hammers and allowed production to increase. Latterly, during the 18th century, the Jordan process was introduced which, through use of a complicated series of knives, allowed for the pulp to be mixed more thoroughly. The result from the use of both machines was the production of shorter fibres which produced a more fragile paper.

Another factor influencing the fragility of paper is the content of the fillings, as, if the percentage of these is greater than 5%, the resistance of the paper is lessened.

A.3.2 EXTRINSIC FACTORS

A.3.2.1 Physical-chemical factors

A.3.2.1.1 Temperature and relative humidity (RH)

While the ambient temperature is high, the reactions which the movement of particles generates produces heat and energy and in turn produces a high degradation in paper, parchment etc, leading to the loss of chemical properties in the materials.

The basic rule is that for every 10% increase in temperature, the useful life of the materials decreases by half. The combination of heat and humidity intensifies a huge diversity of reactions, such as degradation, and creates a favourable environment for biological agents. The action of these micro-organisms results at the same time in other chemical reactions leading to degradation.

The materials of which documents are composed need a determined quantity of water in their molecular structure. They possess properties which allow them to lose or acquire water and, in very humid environments, these materials tend to absorb water. This excess of humidity combined with atmospheric contaminants forms acids which provoke reactions of hydrolysis in the cellulose. The growth of micro-organisms and insects, which cause biological deterioration, is also caused by these conditions.

High temperatures and relative humidity act upon the components of documents and cause degradation. The combination of these factors has a potential for innumerable physical-chemical reactions and for the growth of biological agents, which will generate the destruction of papers, leathers, inks, adhesives and photographic materials.

The adoption of strict parameters is being looked at again by researchers, so that, in many cases, especially in tropical climates, a drastic reduction in temperatures and relative humidity will be sought by mechanical means, which will increase the costs of investment in machinery, maintenance and energy.

Despite this, it is not only for reasons of cost that conservation specialists are now reconsidering the indiscriminate use of systems of climatic control. There are questions about the preservation of the documentary heritage through inadequate use of such systems. It is very common to find that air conditioning systems are switched off at the end of the day, for various reasons, including those of economy. This needs to be taken into consideration when deciding whether to acquire an air-conditioning system. In hot, humid climates, the abrupt changes in temperatures caused by the switching on and off of such equipment can cause condensation, thus threatening the documents and causing serious conservation problems.

In conditions of accentuated humidity, the brief period between switching off and on of lights the next day is not sufficient to allow humidity absorbed by the documents to evaporate completely. Thus when the refrigeration system is connected, more vapour is condensed and more water is absorbed, causing humidity to accumulate in the materials.

A.3.2.1.2 Light - ultra violet rays

Lighting is an important aspect of any architectural plan and many architects like to use the maximum amount of light in their projects for the extraordinary colour it produces, as well as the psychological benefits (comfort of the workers and users) and being economical with energy. However, natural light should be used with caution, as in tropical zones, where the intensity of radiation is greater, the dangers are correspondingly greater.

The basic constituents of archival documents-paper, inks, leathers, photographic materials, films and magnetic tapes suffer greatly from the effect of light. The damage depends on the characteristics of the materials, as well as their capacity for absorption and sensitivity to light, the type of radiation and the length and intensity of the waves and the time of exposure, always remembering that the effects of radiation are cumulative.

Light is a form of electro-magnetic energy known as radiation. The intensity of the radiation depends on the length of the wave. Visible light remains around the centre of the electro-magnetic circle and is only a small part of it. On the other hand, the invisible radiations are much shorter, especially ultra violet rays, and these provoke much more energetic reactions and can cause rupture of the chemical unity. The length of waves longer than an infrared light, radio waves, etc., possess energy and can sometimes vibrate and cause molecules to rotate, causing objects to heat up.

The same effects, of greater or lesser intensity, can be caused by sources of artificial light, especially fluorescent light which throws out vast quantities of ultraviolet light. Archival documents, when well protected in boxes and suitable shelving, cannot be affected by the direct action of light. In reading rooms the light can be 800 lux. In corridors, vestibules and strongrooms the intensity should be reduced by 500 or 450 lux.

A.3.2.2 Biological agents

A.3.2.2.1 Insects

Insects are the silent destroyers. They can act with great speed and cause irreversible damage which is greater in tropical climates because the conditions of temperature, heat and high humidity are considered to be a high potential disaster risk.

The greatest predators of documents and books are classified as thysanura (moths), blattaria (cockroaches), isopterans (termites) and the coleopterans (beetles, fireflies, Spanish flies and weevils). They enter repositories through windows, flooring, ventilation grilles etc.; similarly they can be introduced by means of the acquisition or transfer of documents, for example through wood and other materials already infected.

Insects can find different ways to enter collections, such as through inadequately sealed windows or doors, or those routinely left open; by gaps or cracks in the walls or cavities around piping. Plants around a building offer an excellent habitat for insects which can later migrate to the interior by means of various openings.

Insects which cause greatest damage to documents are silverfish (lepismas), book lice (psocopteros), several types of cockroaches, coleopterans or beetles, woodworm and termites.

Silverfish can be 12.5mm in length. They eat paper sizing, perforate it, especially glazed paper , and damage bindings when attacking the adhesives. They prefer dark, humid areas where they are not disturbed for long periods of time.

Moths live in and grow in dark corners, especially in humid conditions. They destroy leather, paper and photographs. They can penetrate between the leaves of papers and behind furniture placed against walls.

Psocopterans (book lice) are very small yellow reddish insects which can be found frequently between the leaves of books and eat microscopic fungi which grow in paper, and thus their presence usually indicates a humidity problem within the strongroom. They are much smaller than silverfish (1-2mm) and can also eat pastes and gums, but do not perforate the paper. They survive in very humid conditions, eat fungi and the remains of dead insects. They cause devastating damage to the surface of documents and are especially dangerous in collections of herbals.

Cockroaches are omnivorous and are attracted by food remains. They especially like materials which contain starch and proteins and they eat paper, adhesives, leather, parchment and fabric. They can also seriously stain materials with their secretions. In general they prefer dark, humid spots and breed in strongrooms and refrigeration channels. Like moths, they cause damage to the surface and edges of documents and to their bindings. Different species increase in surprising ways, by creating defences against insecticides and unsuitable conditions.

Beetles can attack leather and wool. They are attracted by carpets and by nests abandoned by birds. Some species eat pollen and nectar from plants, while others eat hair and dead skin from humans and other animals.

Coleopterans are a species which varies in accordance with the climatic conditions of each region. Many publications exist about these predators and their description shows characteristics very different in their physical conformation and dimensions. In the course of their growth they undergo a complete metamorphosis; egg, larva, chrysalis and adult. In the larva phase they become very active in the destruction of books, perforate the leaves and, in extreme cases, leave documents illegible.

Despite the fact that termites and woodworm are jointly considered to be the enemies of wood, they can equally attack anything made of cellulose, including paper. Termites can destroy entire collections, including buildings. Their tunnels can cause structural damage in bindings. They are especially dangerous in tropical zones, as there are more than 900 species, including those which live in the earth and those in dry wood. They prefer environmental conditions such as humidity, heat, dark, stale air, associated with cellulose materials. Termites that live in the earth form subterranean nests with very dense populations in direct contact with the earth, or in pieces of wood they find in the earth and in trees. They reach buildings by way of galleries which they construct from a base of wood and even concrete, taking advantage of any structural faults. Those living in dry wood live exclusively in wood. Their colonies are less numerous. Both types of termite attack collections of documents. They can penetrate repositories through furniture or galleries constructed alongside walls. As they have a great aversion to light, they seek out dark areas and the damage they cause never appears on the surface. Despite the fact that in general they eat cellulose, they prefer wood especially the softest varieties. Thus, very often, documentary collections are used as a means of accessing wood.

Different species require different temperature and humidity ranges in order to reproduce, as is shown below:

Type of insect	Temperature	Relative humidity
Cockroach	25-30°C	<70%
Silverfish	16-24°C	90%
Termites	26-30°C	97-100%
Types of beetle	20-28°c	70-90%