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Guide for the storage and exhibition of archival materials

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Foreword

Publishing information

This guide is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 March 2012. It was prepared by Technical Committee IDT/2, *Information and documentation*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This Published Document supersedes BS 5454:2000 and PD 0024:2001, which are withdrawn.

Information about this document

This is an amalgamation and full revision of BS 5454 and PD 0024, and introduces the following principal changes.

- This Published Document follows a different structure from BS 5454:2000. The PD starts with detailed guidance on the nature of documents and best practice for their storage and use and this is followed by guidance regarding a new repository building.
- An update of the types of environment that protect archival materials has been provided, based on research available at the time of publication and in line with requirements specified in PAS 198.
- The guidance has been adapted to recognize a different approach to environmental management. This allows for environmental fluctuations to occur within recommended parameters, such as can occur with seasonal changes, instead of a tight level of stability and control being recommended around set points for temperature and RH.
- Explicit recognition has been made of the needs of archives and library collections managed in historic buildings and other existing repositories.
- A new distinction has been made between the needs of mixed traditional archival materials, where sensitive documents cannot be separated, and those of specialist archival materials, providing four different environmental recommendations.
- More detailed guidance has been given regarding the interaction between the storage environment and reading room and display conditions. A clause containing new guidance for reading room environments has also been included to take into account those documents taken out of storage.
- An emphasis on low energy solutions, first outlined in PD 0024, has been given within the guidance for achieving a suitable environment for archival material.

Use of this document

As a guide, this Published Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this Published Document is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this Published Document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document cannot confer immunity from legal obligations.

In particular, attention is drawn to the following regulations which may be amended from time to time. The commentary in this Published Document reflects the state of the regulations in 2012.

- The Dangerous Substances and Explosive Atmospheres Regulations 2002 [1];
- The Dangerous Substances and Explosive Atmospheres Regulations (Northern Ireland) 2003 [1];
- The Copyright, Designs and Patents Act 1988 [2];
- The Data Protection Act 1998 [3];
- The Building (Amendment) Regulations 2011 [4];
- The Building Regulations (Amendment) Act (Northern Ireland) 2009 [4];
- The Work at Height (Amendment) Regulations 2007 [5];
- The Work at Height (Amendment) Regulations (Northern Ireland) 2007 [5];
- The Equality Act 2010 (Disability) Regulations 2010 [6];
- The Manual Handling Operations Regulations 1992 [7];
- The Regulatory Reform (Fire Safety) Order 2005 [8].

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0 Introduction

Archival storage is intended to prolong the existence of documents and books of all kinds through conservation measures (both preventive and remedial), on the understanding that people will have access to them if necessary. In planning the construction of a new archive repository (whether a new-build or within an existing structure) or reviewing the qualities of an existing location in which archives are held, custodians need to start by understanding the nature of the collections in their care. Different types of archival material can require quite different storage environments and no matter how secure and physically well protected collections are, if the environment in which they are held is unsuitable (too damp, hot, dry, cold or polluted) they will suffer over time, becoming increasingly unusable.

A single archive might contain a wide range of materials having different physical and chemical characteristics. Commonly, an archive can be composed of both modern and ancient documents in good and bad condition, including papers, parchments, wax and resin seals, leather and cloth covered books, plasticized folders, plastic and paper photographs, chemically produced copies (architectural plans, letter books, etc.) and magnetic and optical machine-readable formats. Many documents are themselves made of composite materials and structures, such as books of all kinds; large rolled surveys with booklets sewn to them; albums or scrapbooks with manuscript, photographic and printed items affixed to their pages; video and audio tapes, CD-ROMs, etc. Some of these materials require specialized environments if they are to survive even for a few decades, while many (often older) formats can remain stable for centuries as long as they are protected from damp or careless handling. It is therefore important that custodians consider whether to separate some formats and materials from others and provide different environments most suited to the preservation of each.

Creating an environment that is comfortable for people to use archives is also a consideration for many repositories, even though this might not be the most protective storage environment for the archives themselves. Understanding how archives react to different environments can help custodians to balance the long term survival of archives with their use. Digital copying is an important consideration for custodians in planning the preservation of archives. Such surrogacy will maximize the accessibility of archives in demand and reduce their time out of a protective storage environment.

In addition to preventing a storage environment from jeopardizing the long term survival of an archive, it is important that a repository is able to protect the collection from a variety of natural and man-made hazards, the most common of which are fire, flood and theft.

The recommendations in this guide have been designed to help create and maintain appropriate conditions for document storage and use, and to enable a repository for archives to be built or converted to a high standard. They can be used where an archive is located in a mixed use development and can also be used as guidance for custodians of collections in historic buildings, defining best practice for archival materials while recognizing that best practice for the conservation of a building might require a compromise, based on a risk assessment. They have been developed to cover the United Kingdom's common geological and atmospheric conditions, i.e. fluctuating island weather conditions in a temperate climate, as distinct for example from tropical, alpine, desert or mid-continental climates.

Since the first publication of BS 5454 (the standard on which this publication was based) in 1977, new materials have entered archival collections (e.g. magnetic and optical storage media) and there have been advances in the understanding of the vulnerability of some heritage materials and of the relative stability of others. It has also been recognized that the long term conservation of archives and other heritage collections is not to be achieved at the expense of the earth's environment or through unrestrained energy use. This guidance has been produced in the light of these changes in scientific knowledge and the awareness that a protective environment needs to be achieved sustainably by passive means, wherever practicable.

1 Scope

This guide gives recommendations for the storage and exhibition of documents, including books and other library materials. These recommendations apply to permanent and temporary storage of documents, and equally apply to material which is subject to restricted access or is on display.

The guidance is for use by archivists, librarians, conservators, museum curators, architects, facility managers, contractors, engineers and those concerned with the planning, construction, equipment, maintenance and working of storage repositories and their associated search-rooms, reading rooms and display areas. The recommendations in this guide apply to archives of all traditional archival materials and formats, such as paper and parchment documents, books, maps and plans, and also cover guidance on photographic media common to archives and on more modern machine-readable media.

2 Normative references [1)]

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

BS 1153, *Recommendations for the processing and storage of silver-gelatine-type microfilm*

BS 1449-1 (all sections), *Steel plate, sheet and strip – Part 1: Carbon and carbon-manganese plate, sheet and strip*

BS 4737-4.3, *Intruder alarm systems in buildings – Codes of practice – Part 4: Code of practice for exterior alarm systems*

BS 4971:2002, *Repair and allied processes for the conservation of documents – Recommendations*

BS 5266-1, *Emergency lighting – Part 1: Code of practice for the emergency escape lighting of premises*

BS 5699-1, *Processed photographic film for archival records – Part 1: Specifications for silver-gelatin type on cellulose ester base*

BS 5699-2, *Processed photographic film for archival records – Part 2: Specifications for silver-gelatin type on poly(ethylene terephthalate) base*

[1)] This clause, which contains standard wording used for all European and international standards, is intended to identify all other documents to which reference *might* need to be made in the application of this standard. In practice, it might be possible to apply this and many other standards without recourse to all or any such external references.

BS 5720, *Code of practice for mechanical ventilation and air conditioning in buildings*

BS 5839-1:2002+A2:2008, *Fire detection and fire alarm systems for buildings – Part 1: Code of practice for system design, installation, commissioning and maintenance*

BS 7671, *Requirements for electrical installations – IEE Wiring Regulations – Seventeenth edition*

BS 9990, *Code of practice for non-automatic fire-fighting systems in buildings*

BS 9999, *Code of practice for fire safety in the design, management and use of buildings*

BS EN 3 (all parts), *Portable fire extinguishers*

BS EN 356, *Glass in building – Security glazing – Testing and classification of resistance against manual attack*

BS EN 779:2002, *Particulate air filters for general ventilation – Determination of the filtration performance*

BS EN 1627, *Pedestrian doorsets, windows, curtain walling, grilles and shutters – Burglar resistance – Requirements and classification*

BS EN 1838, *Lighting applications – Emergency lighting*

BS EN 1991-1-1, *Eurocode 1 – Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings*

BS EN 12056-3:2000, *Gravity drainage systems inside buildings – Part 3: Roof drainage, layout and calculation*

BS EN 15095, *Power-operated mobile racking and shelving, carousels and storage lifts – Safety requirements*

BS EN 20534 (ISO 534), *Method for determination of thickness and apparent bulk density or apparent sheet density of paper and board*

BS EN 60332 (all parts), *Tests on electric and optical fibre cables under fire conditions*

BS EN 60529, *Specification for degrees of protection provided by enclosures (IP code)*

BS EN 62305 (all parts), *Protection against lightning*

BS EN ISO 9706, *Information and documentation – Paper for documents – Requirements for permanence*

BS ISO 18902, *Imaging materials – Processed imaging materials – Albums, framing and storage materials*

BS ISO 18906, *Imaging materials – Photographic films – Specifications for safety film*

BS ISO 12606:1997, *Cinematography – Care and preservation of magnetic audio recordings for motion-pictures and television*

BS ISO 18916, *Imaging materials – Processed imaging materials – Photographic activity test for enclosure materials*

PAS 198, *Specification for managing environmental conditions for cultural collections*

3 Terms and definitions

For the purposes of this Published Document, the following terms and definitions apply.

3.1 air-conditioning system
mechanical system that maintains predetermined control of temperature, humidity, air quality and air distribution

3.2 air infiltration
uncontrolled leakage of air through unsealed points and permeable building materials into a building envelope

3.3 aisle
subsidiary passageway between runs leading from a gangway enabling access to shelves for the removal or replacement of documents

3.4 archive
collection of documents intended for long-term preservation

3.5 archival material
type(s) of matter of which a document in an archive is composed

3.6 aspirating smoke detection system
automatic fire detection system in which a sample of the atmosphere in the protected space is drawn by a fan or pump into a fire detector which may be remote from the protected space

[BS 5839-1:2002+A2:2008, **3.4**]

3.7 automatic fire-fighting system
integrated system within a building, designed to control, suppress or extinguish a fire, activated by detection systems

3.8 bay
unit of shelving consisting of horizontal shelves between a pair of uprights or upright frames

NOTE 1 See Figure 1.

NOTE 2 These units may be single- or double-sided.

3.9 bay load
total allowable weight of all the unit loads in a bay not including unit loads which might be stored on the floor of the bay

[BS EN 15878:2010, **3.2.9**]

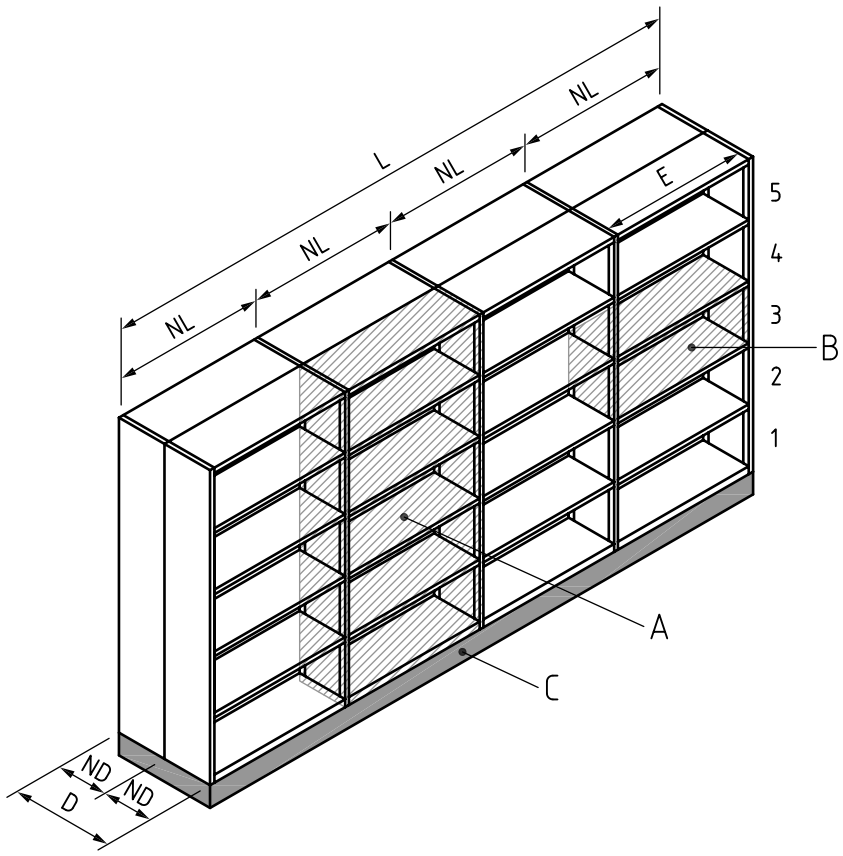
3.10 buffer

3.10.1 alkaline buffer
alkaline content of a packaging material, which reacts with volatile acids to protect the contents of the package

3.10.2 hygroscopic buffer
hygroscopic material that tends to react against changes in the ambient RH by releasing water vapour when the RH falls and absorbing it when the RH rises

3.11 bund
structural upstand that can contain water within a defined space in the event of a flood

Figure 1 **Shelving arrangement**



Key

A	Bay	E	Clear entry of shelving compartment
B	Shelving compartment	L	Length of shelving run
C	Carriage	NL	Nominal length of bay
D	Shelving depth (overall depth of double-entry run)	ND	Nominal depth of compartment

3.12 CCTV system
system consisting of camera equipment and/or other image-capture devices, detector(s), monitoring and associated equipment for transmission and controlling purposes

NOTE This might be used for the surveillance of a defined secure area.

[BS 8418:2010, **3.1.5**]

3.13 conservation
measures and actions aimed at safeguarding cultural heritage (including documents) while respecting its significance, including its accessibility to present and future generations

3.13.1 preventive conservation
indirect measures and actions aimed at avoiding and minimizing future deterioration, damage and loss

3.13.2 remedial conservation
actions applied to an object to prevent or arrest damaging processes

3.14 cooling load
load (measured in kilowatts) that is imposed upon an air-conditioning system in maintaining the repository at the required level of temperature and RH

3.15 custody
responsibility for the care of documents based on their physical possession

3.16 deflection limit
maximum permissible degree of bending in a shelf under the imposed load, usually expressed as a ratio of measured deflection to compartment length

3.17 document
combination of a medium and the information recorded on or in it that forms an item in an archive

3.18 drop-spine box
single-piece book box with its lid and spine-wall hinged at the base allowing access to the bound volume from the spine side

NOTE A drop-spine box can also be used for the storage of the same sized paper manuscripts/documents. See BS 4971 for further information.

3.19 fire resistance
ability of a building component or construction to withstand the passage of flames and hot gases and temperature rise for a stated period, including load-bearing capacity, integrity and insulation

3.20 gangway
principal route in a storage room providing people and trolleys with access to aisles with free space

NOTE The gangway is measured as the narrowest space between any protruding surfaces, including hand-cranks or hand-wheels on mobile shelving.

3.21 hydrolysis
chemical reaction in which a compound is changed by interaction with a water molecule

NOTE An example of hydrolysis in archival material is the gradual breaking of bonds in cellulose molecules of paper, leading to embrittlement.

3.22 medium
material on or in which information is recorded

3.23 membrane
single skin, or part of a skin, of parchment or vellum

3.24 molecular sieve
microporous crystalline material that absorbs and traps other chemical species, incorporated into packaging material to remove off-gassing compounds

NOTE This is often referred to as a pollutant scavenger.

3.25 pre-action sprinkler
dry sprinkler system or one in dry mode in which the alarm valve can be opened by an independent fire detection system in the protected area

3.26 preservation
retention and protection of different formats of archive and library materials and/or their information content in order to maximize their useful life

3.27 record
document created, received or generated in the course of a transaction and forming part of that transaction

3.28 relative humidity (RH)
ratio, defined as a percentage, of the existing partial vapour pressure of water to the vapour pressure at saturation

NOTE It is usually, but not always, equal to the percentage of the amount of moisture in the air to that at saturation.

[BS ISO 18934:2011, **3.13**]

3.29 repository
building, part of a building, or area(s) within a building designated for the long-term storage of documents

NOTE The term repository is not intended to embrace other associated functions such as reading rooms and offices within the same building.

3.30 risk assessment
identification, analysis and evaluation of hazards

3.31 run
two or more connected bays of single-sided or double-sided shelving joined end-to-end

NOTE See Figure 1.

3.32 shelving compartment
shelf space for storing archival materials

NOTE See Figure 1.

3.33 sprinkler system
system of water pipes fitted with sprinkler heads at set intervals and heights, designed to detect, control or extinguish a fire by the automatic discharge of water

3.34 thermal inertia
characteristic of building materials with high heat capacity to absorb and hold heat to maintain a stable room temperature

NOTE Dense materials maximize this effect.

3.35 watermist system
distribution system connected to a water supply, with atomizing media where required, that is fitted with one or more nozzles capable of delivering watermist intended to control, suppress or extinguish fire

NOTE Watermist systems can discharge water or a mixture of water and some other agent or agents, i.e. inert gases or additives.

[DD 8489-1:2011, **3.2.7**]

4 The storage environment for archival materials

4.1 Background and general recommendations

The storage environment chosen for an archive should be based on the range of archival materials that it contains. Although no single set of environmental conditions will be ideal for storing every type of archival material, an emphasis on keeping the temperature low and the RH moderate will slow the rate of decay of all archival materials. Some unusually unstable materials might need to be put into cold storage (see **4.3.3**). For this reason, a survey of the archival materials, including the format that they are in, their condition and the extent and quality of their physical protection should be undertaken prior to selecting a storage environment. Details of environmental vulnerability and risks for a wide range of cultural heritage materials can be found in PAS 198. Where necessary, some materials might need to be removed from a mixed archive and a separate environment provided for them, if they are to be preserved. Clause **4** is divided into recommendations for the storage of traditional archival materials (including books, parchment and paper) and separate recommendations for photographic, audio-visual and electronic media.

An unsuitable storage environment is one of the commonest causes of damage to archives. Different archival materials have different optimum environments for their long term preservation, and the length of time over which a document can be expected to last also depends on how often it is taken out of a protective storage environment and handled (unfolded and re-folded, unrolled and re-rolled, opened and closed, etc.) and the type of environment in which handling or display occurs (see **4.10**).

Damp conditions encourage the growth of mould which is damaging to paper, parchment and other archival materials and can represent a health hazard. Very dry environments can preserve archival materials but can also make some archives, such as folded, rolled and multi-membrane documents, acid-decayed papers and adhesive book structures more inflexible. In a desiccated and inflexible state, these documents are more likely to resist opening and might tear or break when used.

Chemical changes happen in all archival materials over time and can be considered to be part of the natural ageing process. Archival materials such as some wood-pulp papers, 19th and 20th century book leathers, plasticized adhesives and coatings, photographs and photographically reproduced drawings, and some inks are more chemically unstable than, for example, handmade rag papers and parchment. Unstable materials change at a quicker rate as the temperature rises, leading to more rapid ageing. A practical approximation, as given in PAS 198:2012, for all organic materials, including archives, is that reaction rates double with each 5 °C rise. Likewise, high RH can also induce or accelerate chemical change (for example acid hydrolysis of paper and iron gall ink corrosion). Chemical change is often revealed by discolouration or by brittleness and tearing caused by breaks in the molecular chains (polymers) that make up paper and other fibres. Atmospheric pollutants (man-made pollution such as sulphur and nitrogen oxides and natural agents such as ozone) can advance the chemical decay of most archival materials. Some archival materials, such as plastics and some photographic copy papers, can contribute to this decay as they emit gaseous compounds, which, if contained, affect the materials around them and speed up their own decay. All of these factors should be taken into account when determining the storage environment for archives.

NOTE Published research and information can be found in the further reading section of the bibliography regarding the nature and deterioration of archival materials.

4.2 Temperature and RH for traditional archival materials

4.2.1 General

The temperature and RH levels and stability that can be achieved in a repository depend largely on the form and era of its construction. Subclause **4.2** gives guidance on the levels that can, if maintained consistently, prolong the life and usefulness of archival materials. It is focused on what is safe for the materials wherever they are held, not on the building construction itself, for which further information can be found in Clause **6**.

For some archival materials, the levels of temperature and RH suitable for permanent storage can be mutually dependent; that is, one temperature range can require a specific RH range to avoid moisture content becoming too high or too low. The environment chosen for a mixed collection of materials should be based on protecting the most sensitive documents within it. Some very sensitive archival materials (such as cellulose acetate photographs and moving image film) require different conditions from most other traditional archival materials and so should be placed separately in the storage environments defined in **4.3**. A survey should be undertaken to determine the full range of materials in an archive in order to determine and specify the appropriate storage conditions. Documents having significantly different temperature requirements might need to be housed separately from other archival material, but small numbers of documents that have specialized RH requirements may be placed in microclimate enclosures (for example, using conditioned silica-gel) within a general repository. Any separate housing of such material should be recorded so that its provenance is not lost.

Most repositories, especially those housing traditional archival materials, do not yet have the resources for purpose-built storage (or additional separate cold stores). For some repositories, such as those in historic settings, the environmental conditions might never be optimum for their archives, but the responsibility to preserve the collection remains. For those people responsible for these repositories, it is especially important that guidance is available to help them obtain the best available conditions in buildings that cannot provide the perfect storage environment. The environmental recommendations given in Clause **4** start with those that can apply to a wide range of traditional materials in a single setting, and are further refined for separate specialized collections. Recommendations for a new repository are covered in Clause **6**.

NOTE For more detailed examples of archival material requirements see PAS 198.

4.2.2 Mixed archives

Archives having documents created during the past thousand years might contain archival materials which are not removable from their context but which are more sensitive to the level of temperature and RH in which they are held than those archival materials around them. The most sensitive of these items are wax seals appended to parchment and paper documents, and gelatine emulsion photographs (e.g. within mixed albums). Beeswax seals are affected adversely by temperatures below 13 °C, which make them more brittle and precipitate their natural alkane plasticizers into surface crystals. For stability, gelatine photographs require a higher RH minimum at higher temperatures and conversely low RH maximum at lower temperatures. In addition to these sensitive items, some modern colour ink-jet printed documents are vulnerable to colour change in RH below 30% and parchment stored below 35% can be too inflexible to avoid damage when handled.

NOTE 1 For information regarding material damage and deterioration and risks associated with temperature and RH, see PAS 198:2012, Table E.1 and the further reading section of the bibliography.

The level at which mould generally begins to reproduce is around 65 %RH, although this is also dependent on a number of other factors (see PAS 198:2012, **5.2.2**) and so a precautionary maximum for mixed archives, to avoid the risk of periods at this dangerous level, is 60 %RH, recognizing that brief periods (e.g. less than one day) between 60 %RH and 64 %RH represent only a slightly increased risk.

The following ranges of RH and temperature are recommended as a means of preventing even sensitive archival materials referred to within **4.2.2** from being compromised when stored alongside less critically sensitive archival material:

- 13 °C to 20 °C;
- 35 %RH to 60 %RH.

The anticipated longevity of materials decreases as temperature rises. For this reason it is recommended that storage temperatures are kept as low as practicable and for the longest time achievable, recognizing that a very stable environment all year round might not be feasible in anything but a purpose-built repository. The guidance given in **4.2.4** should be used with regard to fluctuation within these recommended ranges.

*NOTE 2 The ranges given in **4.2.2** are based on published research into the characteristics of a range of archival materials including some temperature or moisture sensitive materials such as parchment, wax seals, paper-based gelatine photographs and modern colour digital printing inks. The research used in compiling this guidance is set out in the bibliography and a more detailed list of sources related to materials and risks can be found in PAS 198.*

4.2.3 Paper records storage

Collections that consist only of boxed paper records and which are rarely handled (for example in remote stores) can safely be stored in a wider range of conditions. The temperature in this kind of repository can range between 5 °C and 25 °C and the RH between 25 %RH and 60 %RH. It should be noted that the average temperature across an annual cycle will help to determine the rate of change of papers: the lower the temperature, the slower the rate of chemical deterioration. Likewise, lower RH will reduce the rate of hydrolytic change that can cause deterioration of paper and inks.

4.2.4 Temperature and RH fluctuation

Temperature fluctuation, particularly within the ranges given in either **4.2** or **4.3**, does not itself pose a threat to archival materials but periods of high and low temperature have a different influence on different materials. High temperature accelerates the deterioration of some papers, inks and photographic materials and low temperatures can change the nature of seals made of beeswax (see **4.2.2**). Furthermore, temperature fluctuation can cause a corresponding fluctuation in RH, which in turn causes changes to the moisture content of hygroscopic materials such as parchment, paper, cloth, gelatine adhesives and photographic emulsions. These materials expand and contract as they absorb and lose moisture.

Some fluctuation in the RH of the air in a repository can comfortably be accommodated by most materials, especially if documents are densely packed on shelves or in boxes and are less likely to have immediate contact with RH fluctuations in the air. Equally, the effects of atmospheric fluctuation when documents are static in storage for long periods are less of a hazard than the physical changes caused by handling when documents are desiccated or rapidly losing moisture. However, the long-term effects of expansion and contraction of the documents in storage are cumulative, especially where these changes are wide-ranging and frequent. Over time this can weaken bonds between different materials such as: photographic emulsions on paper, glass or plastic; gilding and pigments or inks on the surface of parchment; or resin seals applied to papers. In some cases, such as linen-lined paper maps, one layer might contract in an environment with high RH while the other expands, thus causing the layers to separate. Depending on the nature of the repository building, maintaining a safe range of moisture content might require measures to control RH, either within a store or where the environment in a store is significantly different from that in its associated reading room (see **4.10.2**).

Gradual change in the RH and temperature from the upper limit to the lower limit (or vice versa) given in either **4.2** or **4.3**, for example as a result of seasonal change, may be considered acceptable if it occurs over a period of a month or more. Even a gradual change of this extent that occurs over a single week in response to weather changes, for example in an historic building with low thermal inertia, can be safe for archives, especially if they are packaged. However, a continuous weekly cycle up and down the ranges will cause a gradually increased rate of deterioration of most archival materials when compared with this rate of change in a very stable environment. While it is preferable to maintain a stable annual average by means of design of the collection space and building structure, it is also safe to allow seasonal movements in RH and temperature in order to improve energy economy, as long as the conditions remain within the ranges given in **4.2.2** or **4.2.3**.

In a well-sealed repository room, heavily insulated against external temperature changes, with very low air infiltration and full of archives, RH and temperature change are unlikely to be in opposition to each other, because the hygroscopic nature of archival materials will dominate the RH conditions inside the room. However, in a repository that has little or no insulation and that is rapidly changed by varying external factors such as direct sunlight (for example a repository in an historic building), the RH and temperature will rapidly cycle in opposition to each other. In a repository falling into these extremes (for example those having irregular thermal buffering and air infiltration, areas where damp can penetrate and/or heating pipes which influence local conditions) the environment will vary and fluctuation of both RH and temperature might be rapid and uneven. In this context the packaging for all documents should be the first consideration in order to protect against the conditions experienced by the archives, along with measures to address the weaknesses in the building and its infrastructure. Fluctuations in RH caused by air conditioning systems can also be protected against by packaging. Air conditioning systems should be set up so that they do not produce a rapid fluctuation or cycle (see **4.6**).

NOTE 1 For small temperature differences (±5 °C or less) in a room at about 20 °C, a useful approximation is that RH will change by ±3% for each 1 °C change (a rise in RH for a drop in temperature, and vice versa).

NOTE 2 Dramatic temperature variations within a collection space are usually caused by the situation of documents next to an exterior wall or floor without sufficient space for air circulation, or situating them close to heaters, air-conditioning equipment or air vents, or in direct sunlight.

NOTE 3 A useful approximation for a space maintained near 50 %RH is that condensation will develop on any surface more than 10 °C colder than the temperature at which the RH is 50%. Precise calculations can be made using a standard psychrometric chart.

4.3 Temperature and RH for photographic, audio visual and electronic media

4.3.1 General

Most photographic and machine-readable media require more precise control over moisture content and fluctuation in RH and temperature than older traditional archive materials. They are usually composite materials, often with layers of hygroscopic media embedded in or on other forms of substrate, making them vulnerable to deterioration caused by different expansion and contraction rates. Most audio visual formats (audio tape, moving image film, video tape, etc.) and photographic negatives and transparencies are constructed from plastic materials, many of which shrink or decay over time and cause distortions that interfere with or prevent access to the sound and/or image they carry. Because they are prone to decay over a shorter time than older materials such as parchment or handmade paper, they can benefit from colder conditions that slow or even halt this decay. Some formats, such as cellulose acetate based materials, should be frozen if the image or information they carry is to be preserved on its original carrier.

All of these formats will degrade faster if they are regularly played or viewed in a normal reading room environment. For this reason, it is recommended that such collections are copied and the originals are stored in a cool or cold (freezing) environment for as much time as possible while the copies are played or viewed instead. With the exception of optical discs (CDs and DVDs) all of these formats will be preserved for the longest time if stored frozen, but most can also have their life extended by cool storage as long as RH and moisture content are managed within the recommended ranges (see **4.3.2**).

Wherever practicable, a separate room or rooms should be provided for these documents, following the recommendations given in **4.3.2** and **4.3.3**. Where separate storage rooms are not available and documents are stored in the conditions referred to in **4.2.2** for mixed traditional archives, they should be individually packaged in a micro-climate designed to provide a different RH environment from the surrounding store (see also **4.3.2**). Photographic, audio visual and electronic media should never be stored in the environment defined in **4.2.3**, which is intended for paper archival materials only.

Alternatively, photographic, audio visual and electronic media should be transferred to a collecting organization with specialized facilities for storing the relevant media.

For magnetic media, an assessment of the risk of magnetic interference should be carried out in accordance with BS ISO 12606:1997, **4.9.9** and **4.9.10** and a suitable storage location should be identified.

*NOTE 1 See **3.17** regarding the definition of document.*

NOTE 2 Cellulose nitrate sheet and moving image film can explode in a fire and cannot readily be extinguished. Further guidance on this can be found in guidance from the Health and Safety Executive, The Dangers of Cellulose Nitrate Film*, HSE 2010 [9].*

NOTE 3 Detailed guidance on the environment for all of these media formats can be found on the Image Permanence Institute website. [2)]

[2)] The Image Permanence Institute website: https://www.imagepermanenceinstitute.org

4.3.2 Cool storage

Cool storage is defined within this Published Document as temperatures falling between 5 °C and 18 °C.

A cool storage environment will slow the rate of decay of the document formats listed in this subclause but will not be as effective as cold storage in achieving this (see **4.3.3**). Cool storage requires less energy than cold storage and at the highest temperature in the range can allow use of the stored documents without acclimatization. At the lowest temperature in the range, documents intended for use should be acclimatized by being placed inside a sealed enclosure for 24 hours until they have reached the same temperature as the reading room, in order to avoid condensation forming.

The RH should be maintained within the range of 30 %RH and 50 %RH in order to be suitable for a cool storage environment. This RH can be achieved in one of two ways: either through the design and management of the storage room itself or through packaging the relevant documents and thereby creating microclimates.

Cool storage may be used for:

- black and white polyester base photographic sheet film negatives and transparencies (including microfiche and aperture cards);
- black and white polyester base moving image film and microfilm;
- black and white photographic glass plates (e.g. gelatin dry plate and collodion wet plate negatives and collodion positives);
- black and white collodion ferrotype sheets (tintypes or melainotypes) and daguerreotypes;
- black and white photographic paper prints of all types;
- colour and black and white ink-jet prints;
- optical discs (CDs and DVDs).

Cool storage can also be used for the following materials, if placed inside a microclimate package conditioned to the RH specified:

- magnetic tape (data, audio, video) on polyester base, conditioned at 25 %RH;
- gramophone discs (acetate, shellac, vinyl), conditioned at 30 %RH.

To achieve an RH microclimate, the packaging should be sealed and include a buffer (such as silica-gel) pre-conditioned to the relevant RH. A humidity indicator should also be incorporated and inspected annually to ensure that the recommended RH is being maintained. Cellulose acetate based material stored in this manner should have a permeable wrapping around each document and a molecular sieve or other type of pollutant scavenger incorporated inside the outer packaging to absorb internally generated acetic acid vapour (see also **4.9.3**). This scavenger should also be monitored and might need to be replaced periodically.

With the exception of optical discs (e.g. CDs and DVDs), all of the above can also be placed in cold storage as defined in **4.3.3** if they are placed inside suitable packaging (see **4.3.3**).

4.3.3 Cold storage

Cold storage is defined in this Published Document as -15 °C ±5 °C.

A cold storage environment can preserve most forms of photographic, audio visual and electronic media in the long term, with the exception of optical discs (compact discs and digital video discs) which should not be frozen because of the risk of layer separation. All documents removed from cold storage for use should be acclimatized by being placed inside a sealed enclosure for 24 hours until they have reached the same temperature as the reading room, in order to avoid condensation.

Since mechanical cooling is unavoidable to achieve the low, cold storage temperatures, it will be more reliable if the temperature is held constant, regardless of external conditions. Cold storage should not fall below -30 °C to avoid the risk of ice crystal formation in archival materials equilibrated to a moderate RH at room temperature.

The RH in a freezing environment is determined by the level of RH present at the time the document was sealed up inside its freezer packaging. The maximum RH at which the document formats listed in **4.3.3** should be packaged is 50 %RH.

All materials selected for cold storage should be prepared and packaged depending on their type and format. Packages should be sealable and airtight polypropylene or polyethylene bags or boxes. Humidity indicators should be incorporated inside freezer packaging, along with a humidity buffer that absorbs moisture when archival material is removed from the cold storage environment. Specialist advice should be sought from a conservator before placing material in cold storage, so that the archival material is correctly identified, that the right level of internal RH will be achieved and that the correct packaging is used.

Cold storage is recommended for:

- colour and black and white acetate photographic negatives and transparencies;
- colour and black and white acetate moving image film;
- cellulose nitrate photographic sheet film and moving image film;
- colour photographic prints, all formats;
- colour ink-jet prints;
- acetate magnetic tape (audio and data).

4.4 Protecting from mould, infestation and pollution

4.4.1 General

Documents accepted for storage should not be brought into the repository until they have been checked for insect or fungal infection and treated, where necessary, in accordance with BS 4971. A separate area should be provided for this purpose and precautions should be taken to confine contamination to it.

4.4.2 Mould

Damp documents should never be placed into a repository as localized damp conditions promote the growth of mould. Individual damp items should be placed in a drying room or cabinet maintained at a RH level below 60 %RH until each document has reached equilibrium with its surrounding air. Books and blocks of paper in other forms of gathering need to be monitored and where possible will need to be fanned out to allow for air penetration. A conservator should be consulted for the storage of damp material. Archives should always be stored away from cold or damp walls or unregulated air vents. Storage equipment should be placed to allow for a gap between archival materials and the surface of walls (see **6.12.6**). A cold zone in a repository might give rise to RH conditions that are higher than the ambient conditions in the rest of the space. This can cause condensation and a higher moisture content within materials, promoting the growth of mould. Repositories with uneven conditions should be monitored in all affected areas (see **4.5**). The causes of these differences should be established and, where practicable, remedied to avoid the risk of undetected mould growth. Where the physical or mechanical deficiencies causing these differences cannot be remedied sufficiently so that the temperature and RH levels conform to **4.2** (for example where there is low thermal inertia in an external wall of a protected historic structure), archives should be moved away from the area affected. Alternatively, air from the acceptable areas of the space can be directed into these zones, balancing conditions across the repository. This can be achieved with fans until the source of damp or colder temperature can be remedied. If mould is germinating, specialist advice should be sought about the health risks and the spread of mould spores.

NOTE Since 65 %RH is the point at which mould can, in general, germinate, it can be assumed that there is a risk of mould in a space usually maintained at X %RH if a drop in temperature reaches (70-X)/3 °C. For example, there is a risk of mould in a room maintained at 55 %RH in any part of the room that is 5 °C colder than the average temperature in the main volume of the space. See also PAS 198.

4.4.3 Pest management

The level of insect activity inside and around a repository should be regularly and seasonally assessed and, where necessary, a programme of pest management initiated. Areas should be kept as clean as practicable and unused space should be accessible for cleaning. Materials that could provide a food source for insects, for example food and drink, pot plants and wool carpets, should never be introduced into a repository (see also **6.6**).

4.4.4 Control of pollutants

Externally and internally generated airborne pollutants should be identified and measured, their impact assessed and measures taken to mitigate their effects in accordance with PAS 198 (see also **4.6.2**).

Silver-based photographic material is vulnerable to chemically induced deterioration of image layers as a result of interaction with atmospheric pollutants, particularly hydrogen sulphide. It is also at risk of deterioration in contact with packaging having an alkaline buffer (see **4.9**).

4.5 Environmental monitoring

4.5.1 General

An understanding of how well an archive is being protected and preserved can only be achieved by continuous monitoring of the environment in which material is stored, handled and exhibited. The information derived from monitoring should be reviewed regularly and the implications of trends in RH, temperature and atmospheric pollutants should be interpreted by a conservator or other specialist with knowledge of the building and its infrastructure. Monitoring alone does nothing to improve preservation conditions; it is essential to respond to evidence from monitoring that shows conditions are outside recommended ranges and rectify the situation.

4.5.2 Equipment

Monitoring devices for temperature, RH and atmospheric pollutants should be provided and used within the repository, whatever the method of environmental control. Recording thermohygrographs, data-loggers, environmental reactivity monitors and sensors linked directly to a computerized building management system can all be used. If a building management system is in use it is also advisable to have some independent monitoring devices. Monitors and their sensors should be situated to provide readings that represent the typical conditions in the storage areas, but account should also be taken of extreme or abnormal conditions that could occur, for example near outside walls or close to a source of heating or ventilation. For comparative purposes, the outdoor temperature, RH and pollutant levels should also be monitored.

Data from continuous monitoring systems (such as those integral to air conditioning or installed telemetric monitors) should be maintained and inspected at least once a week. Recorded data from stand-alone loggers should be downloaded at least once a week if they are being relied upon to establish how an uncertain environment is behaving, or for known environments and longer term analysis once every three months. Data should be retained indefinitely. Where readings show that conditions are outside those recommended in **4.2** or **4.3**, the reason for any discrepancy should be investigated and plans made to remedy any identified problems.

NOTE See also PAS 198 regarding environmental monitoring.

4.5.3 Maintenance

Monitoring devices should be calibrated according to the manufacturers' instructions. They may also be checked against independent devices such as a hand held digital hygrometer, in case they require calibration or develop a fault.

NOTE Even electronic sensors tend to drift and need recalibration from time to time, which is why some independent monitoring is desirable. It is advisable to carry out calibration in a laboratory equipped for that purpose.

4.6 Environmental control

4.6.1 General

Environmental control within the repository should be achieved by provision of a building or an enclosed space within a building that gives high thermal inertia, low air infiltration rates and that has an extensive hygroscopic buffer (see Clause **6**). It should also be capable of providing ventilation, where necessary, as a means of changing air that has become polluted or following an increase in atmospheric moisture leading to levels of RH higher than those given in **4.2** and where no other means of dehumidification has been incorporated. The environment can be more easily controlled if the repository is sub-divided. Where this alone is insufficient to maintain an environment within the parameters recommended in **4.2** or **4.3**, the strategy may be complemented, as necessary, by providing environmental control equipment.

Plug-in mobile dehumidification units, humidifiers, heaters or other electrical equipment can increase the risk of fire or flood in a repository and should only be used where no other means can be found of bringing an existing space within the RH or temperature ranges given in **4.2** or **4.3** and in conjunction with suitable safety cut-out equipment in the event of a malfunction. Sources of damp or weaknesses in insulation leading to colder areas should be identified and addressed first before implementing a mechanical means of control. A new repository should not be designed to incorporate mobile electrical units to be placed within it as a means of controlling the environment.

4.6.2 Air quality, distribution and ventilation

Even in a repository which meets the recommendation in **6.3.2** of no more than two air exchanges per day, air exchange and air distribution might be insufficient to maintain internally generated pollutants below the recommended limits defined in PAS 198 or to balance temperature and RH where weaknesses in historic structures cannot be remedied (see **4.4**). An internal fan system can be used to distribute and balance air across the repository where conditions in localized zones are not within the ranges given in **4.2** or **4.3**.

New repositories should be provided with a controllable mechanism for ventilation with clean fresh air where it is desired as a means of managing temperature and RH and controlling internally generated pollutants. It should be used at times of the year or of the day that allow the fresh air to bring the internal air into the recommended conditions (see **4.2** and **4.3**). It should incorporate filtration to reduce external pollutant concentration levels that are above the acceptable levels defined in PAS 198. It should provide even distribution so that all areas of the repository are reached. Where internally generated acetic acid vapours are reaching >100 $\mu g/m^3$, the air inside a repository should be ventilated with fresh air to reduce levels.

The fresh air used to ventilate should not contain atmospheric pollutants at levels above those defined in PAS 198. Fresh air intakes should not be located close to sources of pollution, excessive moisture or heat. Dust should be collected through a coarse filter in accordance with BS EN 779:2002, Clause **6**, G3, and a fine filter in accordance with BS EN 779:2002, Clause **6**, F7. Materials used for filters should not be damaging to archival material. Filter performance should be regularly monitored and filters should be maintained according to manufacturers' instructions. Any equipment that produces ozone should not be used as this can be harmful to archival materials.

Air diffusers should be located inside the repository such that they allow for air circulation around loaded shelves. It is important that shelves are adequately ventilated to allow the free movement of air. Wherever practicable, the sides and backs of both fixed and mobile shelving should be open to allow the free circulation of air. There should be a distance of at least 150 mm between the floor and the lowest shelf, as well as between the ceiling and the average line of upper edges of objects stored on the top shelf. There should also be a distance of at least 50 mm between the top of the highest document on each shelf and the bottom of the shelf above.

4.7 Air-conditioning

4.7.1 General

New repositories for mixed archival collections should, wherever practicable, be designed to maintain conditions within the parameters given in **4.2** without the need for air-conditioning. However, where the location of a new repository is deemed to make such stability unlikely or the thermal properties of an existing building and its ventilation are insufficient to maintain the recommended environment, central station air-conditioning units with humidification and dehumidification facilities and temperature controls may be installed in order to enable the repository to conform to **4.2**.

Where an air-conditioning system is installed, it should be capable of providing the environments specified for different archival materials in accordance with **4.2** or **4.3**. Account should be taken of the space required for the air distribution ductwork connected to the air-conditioning plant. The plant should be situated outside the repository. An alarm system should be installed to alert staff to any mechanical malfunction in the air-conditioning plant. The installation of a standby (or duplicate) air-conditioning plant should be considered.

4.7.2 Air circulation rates and fresh air

In an air conditioned building, the rate of air circulation should be determined from the cooling load to maintain the recommended temperature and RH given in **4.2** or **4.3**, as appropriate.

In order to prevent unregulated air from being drawn into the repository and thereby undermining the intended control over RH and temperature, positive pressure should be maintained at all times by including up to 5% fresh air make-up into the air flow ahead of the air conditioning units and by operating return fans at a slower rate than supply fans. See also **4.6.2**.

4.7.3 Control strategy

The control strategy for managing temperature and RH in a dehumidification unit using a chiller battery to remove moisture should always give priority to humidity levels and not to temperature levels, in order to prevent dehumidification cooling from being switched off when the required temperature level of room air is reached. Off-coil air should be re-heated when it is below the recommended levels given in **4.2** and **4.3** as a consequence of dehumidification cooling.

Air sensors located in the return air duct that are linked to the controls should be provided in order to regulate air conditioning systems. Return and supply ductwork passing through spaces outside the repository should always be insulated to reduce changes of temperature affecting sensors used for controlling air conditioning units, especially if sensors are located in return ductwork.

Control strategy should not result in rapidly fluctuating air temperature or RH. A graph of conditions should reveal an even, sinusoidal wave pattern.

When temperature and RH levels are within the ranges given in **4.2** or **4.3** and in accordance with **4.4** and **4.7.2**, fans may be turned off, for example, overnight or for longer periods of time until conditions start to extend beyond the recommended ranges.

4.7.4 Maintenance

Air-conditioning installations should be kept clean and in good working order and this should be taken into account in their design. Expert advice should be sought about routine maintenance of the installation and precautions that might be necessary to avoid health hazards.

A stock of critical replacement parts such as fan belts, filter bags, heater elements and humidification bottles, electronic fuse and switching modules should be identified and kept on site at all times so that their replacement does not result in periods of down-time while replacements are sourced. The choice to include an air conditioning unit should be based on an understanding that conditions cannot be kept within the recommendations given in **4.2** and **4.3** without it. Archival materials are at risk of damage in an environment outside the recommendations in **4.2**. Mould can rapidly spread if RH is above 65 %RH for periods of a week or more, so down-time should be avoided.

4.8 Packaging of books, paper and parchment

4.8.1 General

Unbound documents, loose maps, plans and photographic items and bound volumes in a vulnerable condition should be protected by packaging. Archives and books vary widely in format and it is essential that packaging is of the correct size, construction and material to suit the particular document(s) enclosed.

Packaging should be:

a) suitable for its purpose (i.e. long term or short term storage and the accessibility of its contents);

b) designed to fit the document(s) without them being folded or otherwise adapted to fit the container;

c) strong enough to withstand handling and the weight of the document(s) they contain;

d) designed to protect the contents against pollutants and light;

e) constructed of materials that have no adverse effect on the document(s) enclosed as a consequence of vapour exchange or direct contact, in accordance with Annex A.

Where packaged documents are placed inside a larger archive box, these boxes should not be overfilled.

When selecting archive boxes for use, the ease with which they can be handled should be taken into account.

Packaging materials and applications should conform to the relevant clauses in Annex A.

*COMMENTARY ON **4.8.1***

Boxes and enclosures provide good protection. They may be in various forms made from different materials. The more common boxes and enclosures are described in Annex A.

The advantages of using boxes and enclosures for storage are that:

1) minimum intervention is required;

2) they provide good protection from disasters, e.g. water damage;

3) they provide protection from pollutants and environmental changes;

4) they provide protection from physical contact in storage;

5) they provide protection during transit;

6) they hold loose material securely together;

7) they facilitate handling and effective space management and shelf usage;

8) they provide easy identification/location of documents without handling.

The disadvantages of using boxes and enclosures are that:

i) theft or loss of items is less easily detected;

ii) they might trap harmful substances present in the document;

iii) the contents are not readily visible for monitoring;

iv) they create bulking and so take up more space;

v) there is physical contact with the document.

4.8.2 Marking of packaging

Boxes and wrappers used in packaging should be clearly and permanently marked with information that facilitates repacking of the contents as well as correct replacement in the repository. Where a portion of a binding or of the contents is stored in a separate place, this may be recorded directly on the box, but should also be recorded separately in a location index.

Where labels are used for indicating the contents of the box, these should be printed with permanent ink and the boxes themselves should be given a location mark in case the label is lost.

4.8.3 Loose sheets

Documents in the form of loose sheets or membranes that are to be stored with other documents of similar form or content should be stored flat, or retained in their original folds, and should be stored in open-sided archive envelopes in card folders inside rigid boxes of the type recommended in **A.2**.

Care should be taken to protect seals on single sheet documents. It is inadvisable to place more than five documents with applied seals into an open-sided archive envelope. Single sheets that are deemed to be particularly fragile, significant or valuable may be mounted and housed in plan chests. Single sheets may be attached with guards to support-sheets of heavier weight and bound in a file or fascicule system.

NOTE See BS 4971 for methods and materials.

The method of connecting support sheets should allow for dimensional change.

4.8.4 Outsize documents

Outsize documents (see also **6.12.8**) that do not fit conveniently into the storage system being used, such as maps, plans and working drawings, should not be dissected or dismantled for storage.

Depending on their nature and physical state they should be stored in one of the following ways:

a) flat in portfolios (see **A.2.2**);

b) rolled round a cylinder (see **A.3**);

c) in appropriate vertical storage (see **6.12.11**).

4.8.5 Rolled documents

Documents that have been designed to be rolled, such as account rolls and inventories, should remain in their rolled form for storage, wherever practicable.

Rolled documents should be packaged and stored:

a) where necessary, rolled around cylinders (see **A.3**) for support;

b) wrapped with archival paper and boxed individually or in groups; or

c) stored separately within a square cross-section tube or box.

Where it is necessary to store rolled documents flat, they should be packaged with an archival board support and enclosed in a four flap enclosure, covering the document completely (see **A.2.3**).

Rolled documents should be copied as the continued rolling and unrolling of documents during handling can cause them to become damaged.

*NOTE Rolled storage is suitable for large documents such as maps that cannot be stored flat owing to their size. Rolling such documents around a rigid cylinder protects them for both storage and handling, but is more demanding on storage space. Recommendations concerning the material and dimensions of cylinders are given in **A.3**.*

Small rolls may be stored within a box, each roll wrapped around a cylinder to protect it from the pressure of other rolls. It is essential not to overfill boxes. The weight of the boxes should be carefully controlled so that they remain easy to handle and transport by staff. Large rolls that are not to be stored in boxes should be wrapped. Cloth, linen bags or archival-specification kraft paper or manila are recommended wrapping materials. There might be cases where it is preferable to store a rolled document flat, for example when it has become weakened or damaged.

4.8.6 Bound volumes

Custom-made book boxes provide the most effective means of protecting bound volumes on the shelves from physical damage whether stored upright or flat and should be used wherever practicable (see **6.12.13** and **A.2**).

The degree of protection required depends on the physical state of the bound volume and the type and amount of use it is likely to receive. Where bound volumes are placed on top of one another, their weight should be taken into account to avoid undue pressure on the volume at the bottom and larger bound volumes should be placed under smaller bound volumes.

Bound volumes having limp vellum or parchment covers (i.e. without boards) and bound volumes with vellum text blocks should be stored in a custom-made drop-spined box. If boards or limp covers are larger than the textblock and the volumes are to be stored vertically, a text block support should be incorporated into the box.

Bound albums, which often contain archival materials of differing thicknesses and/or photographs, can be damaged by compression if they are laid flat or stored in piles. They should be stored upright, in a drop-spine box with a text block support if the cover is larger than the internal leaves.

4.8.7 Seals and lead bullae

Documents with pendant seals should have packaging that protects both seal and document.

The following options are recommended for packaging documents with pendant seals:

a) insertion into boxes that permit storage of flat, folded or rolled documents with their seals inside the same package and are horizontally shelved;

b) insertion into acid-free boxes that are strong enough to withstand crushing and that are made of unbuffered purified cellulose fibre;

c) sealed documents individually packaged or separated by fixed and stable dividers;

d) insertion into textile bags that are easy to open and close and made of materials that are anti-static, permeable but not hygroscopic (e.g. polyester) and lint free (i.e. having no loose fibres).

Seals should be supported in such a way that neither they, nor their fasteners, nor the document to which they are attached are subjected to stress.

Lead is particularly vulnerable to corrosion in the presence of low concentrations of organic acids from storage materials. Therefore it should not be stored on or near oak, unseasoned wood, fresh paint or adhesive that can emit such acid vapours.

Storage, display and mounting materials used for lead bullae should be known to be inert towards lead (see PAS 198 for further information regarding lead). Otherwise the lead should be enclosed in its own microenvironment, for example, inside an airtight box made of an inert material. Documents having lead seals should be stored in rigid containers which do not exert pressure on or rub against the seal and which contain no internal wrapping materials. The best preserved side of the bulla should lie face down in the container. Cotton gloves should always be worn while storing and handling lead bullae and they should be given temporary protection during consultation, such as a support or mount.

Seals made of cellulose acetate break down slowly, emitting acetic acid gas. Any dye they contain can also migrate to the nearest surface. They should be stored in acid-free vented boxes made, where practicable, of a material containing molecular sieves or other types of pollutant scavenger (see **A.5.3** and **A.5.4.3**).

4.8.8 Other traditional archival materials

Archival materials such as palm leaves or barkcloth may be treated as paper. Documents should generally be stored flat, but textiles and large sheets may be rolled. Fragile or fragmentary papyri may be stored between glass sheets. Wooden objects such as tally sticks may be wrapped in acid-free tissue and stored with other archives. An appropriate conservation expert should be consulted for the storage of fragile, complex or unusual objects that form part of a collection.

NOTE See BS 4971 for more information regarding acid-free tissue.

4.9 Packaging and care of photographic, audio-visual and electronic media

4.9.1 Glass plate negatives and slides

Glass plate negatives and slides include collodion wet plate negatives and silver gelatine dry plate negatives, where the image is supported by glass. Nitrile gloves should be worn when handling negatives and slides. They should only be handled by the edges of the glass. The emulsion side (the image side) should always be placed face down on a clean, dry, dust-free surface.

Where negatives or slides are stored in wooden boxes, they should be removed and placed in paper enclosures and boxes conforming to **A.5.4.3**.

Slides which have a glass protection placed onto the emulsion side (the image side) may be placed in polyester sleeves (see **A.5.5**) and/or envelopes conforming to **A.5.4.3**. These should be placed into boxes that are suitable for storing photographic archival materials.

NOTE Further information can be found on the Canadian Conservation Institute Notes 16/2, Care of black-and-white photographic glass plate negatives *[10].*

4.9.2 Paper-based photographs

Photographs on paper should be packaged either inside polyester sleeves or using specialized papers and boards, as described in Annex A. They should never be handled without the use of nitrile gloves as the oils and sweat from fingers react with the silver halide in photographic emulsions that forms the image in most black and white formats. Cotton gloves should not be used for handling photographs because oil and sweat from hands can still reach the photographic emulsion.

4.9.3 Photographic sheet film negatives and transparencies

Sheet film negatives of many different formats are common in archive collections. Cellulose nitrate sheet film is not as prone to deterioration as moving image film (see **4.9.4**) because its formulation is different and the gelatine anti-curl layer on all but the earliest formats of sheet film blocks or slows the effects of atmospheric pollutants and oxygen that can trigger the onset of degradation. However, cellulose nitrate in any form cannot be extinguished when alight and large quantities of sheet film negatives considerably increase the fire load in an archive (see also **4.9.4**, Note 3). Sheet film negatives in large numbers can explode in the event of fire and should be packaged individually using paper sleeves. Acetylated cellulose plastic negatives and transparencies of all forms (diacetate, acetate butyrate and triacetate, etc.) are unstable and eventually shrink and release acetic acid vapour (known as vinegar syndrome) which can affect neighbouring materials. Sheet film negatives and transparencies should be packaged in individual paper sleeves and double-enclosed freezer packaging and placed in cold storage (see **4.3.3**).

4.9.4 Moving image film

Moving image films should be wound on plastic bobbins or cores with the emulsion side facing inwards. The films should have protective leaders at both ends of the reel. The films should then be placed singly in corrosion resistant metal or inert plastic cans appropriate to their gauge and size. Unless stored at or below 0 °C, or containing a molecular sieve or other type of pollutant scavenger, these cans should have ventilated lids to allow air exchange. Other materials, such as acidic paper, should be removed. Where practicable, separate magnetic soundtracks should be stored apart from their associated images in conditions appropriate for magnetic media (see **4.9.9**). Film cans should be stored flat on shelves no more than 300 mm in height.

Most cinematographic film made before 1951 is likely to be on a cellulose nitrate base. Cellulose nitrate is highly flammable and can be dangerous, producing toxic gases and in extreme cases, exploding in the event of a fire. It is essential to take advice about the storage, copying or disposal of such film. It is preferable that photographic records and cinematographic film on a cellulose nitrate base are not kept in the repository but are copied onto safety film in accordance with BS ISO 18906, BS 5699-1 and BS 5699-2. Where the originals are kept, it is essential that they are stored in a separate, well-ventilated repository at a low temperature.

NOTE 1 Attention is drawn to the Dangerous Substances and Explosive Atmospheres Regulations 2002 [1] and the HSE guidance document, The dangers of cellulose nitrate film *[9].*

Cellulose acetate film should be inspected for evidence of acetic acid decomposition, as the emitted gases can be harmful to other archival materials. Magnetic soundtracks on acetate cine stock are particularly vulnerable to acetic acid decomposition. Affected film should be isolated from other archival material, duplicated (if permissible) and frozen. Specialist advice regarding such archival materials should be sought at the earliest opportunity.

NOTE 2 Attention is drawn to the Copyright, Designs and Patents Act [2].

NOTE 3 Audio tapes with cellulose acetate backing material were produced from the mid 1940s to 1970s. They are particularly vulnerable to decomposition and deformation in storage and can be very fragile. It is advisable to give high priority to the preservation of the audio signal by copying, an activity which is best carried out by specialists.

NOTE 4 BS ISO 18934 covers storage conditions for films.

4.9.5 Microfilm

Silver gelatine type microfilm should be processed and stored in accordance with BS 1153. Older microfilm might be on cellulose nitrate or acetate and conform to **4.9.2** and **4.9.3** with regard to storage. Replacement polyester copies should be made, where permissible.

NOTE Attention is drawn to the Copyright, Designs and Patents Act [2].

4.9.6 Gramophone records

Each gramophone record should be placed in a soft polyethylene inner cover, inside a tough card outer cover with a flap. To reduce the ingress of dust and dirt, the inner cover and outer cover should be oriented so that their respective openings do not coincide. Where the original commercial cover and accompanying literature are to be preserved, they may be stored separately. Records should be stacked upright on shelves in metal cabinets divided into sections between 150 mm and 225 mm, with sufficient lateral pressure applied to the records to prevent warping. Records should be grouped according to size, and different sizes should not be stored together. The cabinets should have louvres or other openings to provide free access of air. Shellac discs, which are fragile, should be stored on static rather than mobile shelving.

4.9.7 Sound cylinders

Specialist advice should be sought for the preservation and copying of sound cylinders.

NOTE Attention is drawn to the Copyright, Designs and Patents Act [2].

4.9.8 General machine readable documents

Machine readable documents and copies of documents should be periodically inspected to check their continued functionality. Where necessary, they should be copied to replace deteriorating documents and to allow for future access. For security and environmental reasons, hard copy formats should be kept apart from the originals.

Rewriteable material should be protected against both accidental and deliberate erasure. Magnetic tapes and discs, optical discs and tapes and related devices need special protection to prevent distortion or obliteration of the recording or data.

NOTE 1 Attention is drawn to the Copyright, Designs and Patents Act [2]. Attention is also drawn to the Data Protection Act [3].

Where permission has been granted to make copies, two copies should be made and one copy kept off-site.

NOTE 2 More information regarding digital preservation can be found in the National Archives digital preservation publication, Guidance note 3 – Care, handling and storage of removable media *[11].*

4.9.9 Magnetic media

Tapes should be supported at the centre, not the rim. Each tape should be kept in an aluminium, acid-free card or inert plastic container to exclude dust. Because many tape formats are on cellulose acetate bases, unless they are stored at or below 0 °C, these containers should include a molecular sieve or other type of pollutant scavenger or should allow air exchange, for example by having either a ventilated or a loose-fitting lid. Tapes on stable archival materials such as polyester may be placed inside a soft, self-sealing polyethylene bag.

Magnetic floppy discs should be stored standing upright, inside polypropylene or other inert plastic containers.

NOTE Specific guidance on the storage of magnetic media is given in BS 4783 and BS ISO 12606.

4.9.10 Effects of magnetic fields

Magnetic fields can damage or erase magnetically recorded material. Therefore electrical or electronic apparatus that could cause such erasure should not be permitted in the repository. Magnetic media should also not be brought into the vicinity of such apparatus. Magnetic media should not be stored near, or brought near, power supplies, electricity generators and cables or lightning conductors.

4.9.11 Rewinding

Magnetic print-through (in which the information on one layer of magnetic tape can become imprinted on the next) is unlikely if regularly used materials are stored in accordance with Annex A. Rewinding should therefore be kept to a minimum, but tapes should be wound to one end after use and before storage. Single-track tapes may be stored reversed or tail out, and rewound at playing speed before use. After use, all tapes should be stored neatly wound with no turn of the tape projecting above the general mass. If necessary, the tape should be run at playing speed to achieve this.

4.9.12 Optical discs (CDs and DVDs)

Where the interior plastic surrounds, spokes and paper inserts are removed, optical discs may be stored in the manufacturers' hard plastic cases.

NOTE Plastic surrounds, spokes and non-archival paper inserts can give off corrosive gases in storage.

Discs should be encased in a sleeve or self-sealing bag made of an inert material such as polypropylene but one disc should not press directly against another in storage. This also applies to discs kept in other forms of container.

4.10 Time out of storage

4.10.1 General

The recommendations in **4.2** and **4.3** are for storage conditions that can help to prolong the existence of archives in a useable condition. It is recognized that the lower end of the temperature ranges are usually not suitable for people in a reading room or display area. The majority of documents spend most of their time in storage and so short periods in a warmer environment are unlikely to compromise their stability or condition. Archives should be returned to the storage environment as soon after their use as is practicable. Where a document is repeatedly being used and consequently regularly moving from storage to reading room and back, it should be a priority for surrogacy so that its longevity is not compromised.

Movement from a store within the temperature range given in **4.2.2** (13 °C to 20 °C) to a room at 21 °C, for example, is unlikely to cause damage to most traditional archival materials if the RH level is the same in both spaces. Archives stored at the lower end of the ranges given in **4.2.3**, **4.3.2** and **4.3.3** (e.g below 10 °C) or in cold storage (e.g. -15 °C) will be at risk of damage caused by condensation forming on the document surfaces. This is particularly damaging to magnetic media, gelatine photographs and some inks and pigments. Movement back into a cold store from a warm reading room might cause document surface condensation from moisture on the inside of polyester sleeves or other impermeable encapsulation.

4.10.2 Reading room environment

To minimize the impact of use on archival materials, the difference between the environment in a reading room and the environment in its associated storage room needs to be measured and, where necessary, controlled. The reading room environment should be monitored in accordance with **4.5** and readings compared regularly with those from the storage environment.

To avoid the risks associated with handling desiccated and inflexible documents (see Note 1 and **4.1**), the RH in a reading room should be the same or higher than the RH in the storage room and should not be permitted to drop below 40 %RH if the collection includes parchment, leather or photographic materials and books with gelatine adhesives.

NOTE 1 Maintaining the RH in reading rooms above 40 %RH will reduce the rate of drying of strongly hygroscopic materials such as parchment. If, at the moment of handling, a folded or rolled parchment document is losing moisture, shrinking and becoming less flexible, it is likely to resist opening and might tear. If, however, the reading room RH is higher than in the storage room, the document will be absorbing moisture, relaxing and becoming more flexible at the moment of handling, which will reduce the risk of damage.

It is recommended to maintain the reading room environment at a level of 65 %RH or below for as much time as is practicable. Allowing it to remain at or above this threshold will encourage mould to germinate, which can pose a risk to human health and contaminate the archive. If the RH level in a reading room or display area is below 40 %RH, localized humidification might be necessary.

For a reading room, the temperature may be higher than the range recommended in **4.2** but should be maintained below 25 °C in order to avoid damage to sensitive archival materials such as those listed in **4.2.2** and **4.3**. The reading room should be kept as cool as the comfort of readers allows.

Measures that may be taken to reduce temperature in an existing reading room include: blocking direct sunlight; improving insulation; using cold lighting (e.g. LED lamps); keeping heating off when the reading room is closed (e.g. at night) and reducing or controlling heating when it is open; introducing ventilation. Reducing the temperature can also be used as a means of increasing RH to prevent excessive dryness and/or difference between a reading room and a storage repository.

Where it is necessary to move archival materials from the cold storage conditions recommended in **4.3.3**, or below 10 °C, they should be placed inside a sealed container when in the repository, moved to the reading room to acclimatize and only removed once they reach the same temperature as the reading room. Archival materials returning to a cold storage environment should always be reconditioned and resealed in accordance with **4.3.3**.

Light in the reading room should be free of ultra violet (UV) radiation. Levels and periods of light exposure in use should be monitored. Direct sunlight on documents should be avoided. Blinds or other window coverings should be installed in a reading room to manage sunlight.

NOTE 2 Further information and guidance regarding the effects of light on collections, light levels and monitoring is given in PAS 198.

4.10.3 Exhibition environment

Documents should not be placed on permanent display. Display periods should be calculated by an understanding of the impact of the display environment on the documents. When displayed in accordance with **4.10.3** and **4.10.4**, the display period calculated should be based on light exposure, usually measured in lux hours, as the only difference between a storage environment and a display is the illumination of the documents. Traditional archival materials should always be exhibited within display cases capable of maintaining RH levels within those recommended in **4.2** throughout the period of exhibition. The temperature for the display of books, paper and parchment documents in a stable and un-deteriorated condition should not:

a) drop below the bottom of the ranges specified in **4.2**;

b) exceed 25 °C; and

c) remain above 22 °C for the duration of an exhibition.

Documents that are in a weak and deteriorated condition or that are vulnerable to higher temperatures should only be exhibited within the ranges specified in **4.2** and **4.3**, as appropriate.

4.10.4 Exhibition lighting

Documents, and especially photographs, are damaged by exposure to UV radiation. Exhibition light sources should be free of UV radiation or it should be removed by the use of filters. Documents of different forms vary in their sensitivity to light levels (measured in lux) and exposure (measured in lux hours). Calotype and cyanotype photographs are, for example, highly sensitive to light exposure while black and white silver gelatine photographs are considered to have low sensitivity. Coloured papers fade and wood pulp papers discolour rapidly in high light levels while undyed papers made of rag fibres are likely to change slowly. Coloured inks, especially digital printing inks, are highly vulnerable to light damage but carbon inks can withstand slightly higher exposure.

Custodians proposing to display documents should establish the sensitivity of the specific materials intended for display and set the light levels accordingly, recognizing that low light levels reduce fading and discolorouration. It is important to take into account background lighting in the display area as well as that in the display case.

NOTE PAS 198 contains requirements for the environmental conditions for collection items, which can be useful when planning document exhibition.

4.10.5 Display cases

Display cases should not be placed in areas that are subject to extreme or rapid variations in temperature. Display cases should be glazed with anti-bandit glazing, in accordance with BS EN 356, of a kind that also absorbs UV radiation. The lids should have strong stays and hinges so that they can be raised and kept open until they are nearly vertical to allow space for large items to be moved in and out easily. Upright cases should have similar qualities allowing easy access from the sides.

4.10.6 Seals and lead bullae

Where a seal or similar object is attached to a document on display, the seal should be supported by a mount in such a way that the weight of the seal is borne by the mount and not by the document or its cords or tags.

*NOTE For guidance on lead bullae, see **4.8.7**.*

4.10.7 Display of bound volumes

A bound volume on display should be supported on a solid surface in such a way that no part of the bound volume is under stress. The kind of support necessary depends on the volume's size, shape and weight, and whether it is to be displayed open or closed. A typical codex binding structure can be seriously strained if it is displayed open and tilted up at an angle of more than 25° from the horizontal. The greater the angle the greater the stress, and for an aged binding structure the angle of display might be crucial. Where a ledge supports the volume, the ledge should be long enough to support the bottom edge of the binding at all points and be of the same depth as the volume as displayed; if the volume is closed, the ledge should be strong enough to support both front and back boards. Whether the volume is displayed closed or open, the text block should have its own support. Large and/or heavy volumes should always be displayed on a horizontal surface. When displayed open, they should always be supported by angled supports or a cradle.

A display case for bound volumes should be at least 320 mm deep at the front to allow space for a volume with limited opening to lie partially open on a cradle. The display deck should be horizontal or tilted slightly, not more than 25° from the horizontal. Its distance from the top of the case should be adjustable.

Where a bound volume is to be held open, straps can be used to retain the pages. Straps should be made of a material that has no chemical effect on the archival materials of which the volume is composed and should not be fastened directly to the volume. A double strap may be used to avoid putting pressure on the page on display. The lower strap should go over a page that has little or no text or illustration that might be damaged by a strap, so that the page on display needs only a light retaining strap. The retaining strap should hold the pages firmly but not tightly.

5 Storage repository site

5.1 Avoidance of hazards

When selecting a storage repository site, a risk assessment should be undertaken to identify and document the hazards of each potential site and the likelihood of each of the identified hazards causing damage. The risk assessment should include an assessment of whether preventive conservation measures can be implemented to minimize the risks identified and also whether after measures are put in place the level of risk is likely to be acceptable.

Hazards fall into one of three categories:

a) those which result in the sudden loss of, or extensive damage to, archival material (e.g. the collapse of the building, fire, flood or serious contamination resulting in the site becoming inaccessible);

b) those which can result in obvious damage to the archival material (e.g. insect or animal attack); and

c) those which do not result in obvious visible damage but which can cause irreparable long-term damage (e.g. exposure to dust and polluted air).

With regard to **5.1**a), a detailed risk assessment should be made before making a decision to build on a potential storage repository site. The risk assessment should cover hazards associated with the following:

i) sub-surface road, rail or similar-sized tunnels, or other such sites that are liable to subsidence or landslides;

ii) flooding (whether of natural or man-made origin);

iii) sites or areas used for the storage or processing of highly flammable materials (e.g. petro-chemicals, explosives, paint and tyres), at risk from fire or explosions, or at risk from water or chemicals used to deal with such hazards;

iv) elevated roadways, railways or tramways;

v) nuclear power stations, plants or other radioactive facilities;

vi) airports and their associated flight paths;

vii) overhead high voltage power lines and substations; or

viii) defence establishments.

With regard to **5.1**b), a storage repository site should not be selected that is:

1) on or immediately adjacent to untreated contaminated land, or landfill sites; or

2) adjacent to a place or a building used for the storage or processing of perishable foodstuffs, a waste management facility or similar such site that might particularly attract rodents, insects and other pests.

With regard to **5.1**c), a storage repository site should not be selected that is:

I) adjacent to an incinerator, working quarry, open cast mine, cement works, stone crushing plant or other such installation emitting harmful gases, smoke, dust, etc.; or

II) in an area where the air is known to be polluted, for example, from industrial processes.

In order to minimize the harmful effects of exposure to sunlight and to strong winds that affect air infiltration, careful attention should be paid to orientation, landscaping and the site's microclimate.

Flooding has proved to be a considerable hazard to archives. It is therefore advisable to carefully consider sites that are above the 100-year flood level which are allegedly free from the risk of flooding. It is also essential that where a history of springs exists on a site that this is taken into account, as heavy rains can reactivate them.

*COMMENTARY ON **5.1***

It is important for custodians of archive buildings and their governing bodies to have in place carefully thought-out strategies for document preservation, access, security, fire prevention, prevention of disasters and recovery in the event of a disaster. It is also beneficial to put a full assessment of the site of the building and protection against risks identified at the forefront of any preservation strategy.

*It is impracticable to identify every hazard that might be associated with a site, especially as different locations are subject to different hazards. Therefore the list given in **5.1** is illustrative rather than comprehensive, to help identify general ones that require consideration. No site can be completely free from hazards, but when selecting and planning for a repository, the probability of certain hazards causing loss or damage to archived material can be assessed and taken into account.*

*Other considerations associated with the risks of flooding include drainage (see **6.5**) and a disaster recovery plan (see **7.1**).*

Further information regarding flood risk in development can be found in BS 8533.

5.2 Security

5.2.1 General

As archives are irreplaceable and their authenticity can often be established only by proof of unbroken custody, they should be rigorously protected against theft, vandalism, unauthorized alteration and casual damage or disturbance caused by inexpert or careless handling. In order to maintain unbroken custody of archival material, unauthorized and unsupervised access to any room in which it is stored should be forbidden. Equipment not required for the storage of archives should not be kept in a repository.

An overall security strategy based on a risk assessment should be implemented that includes the building, its contents and its use.

5.2.2 Security of the storage repository site

Where the repository is not part of a larger building, it should, wherever practicable, be on a stand-alone or island site with restricted access around the whole perimeter. The perimeter should be clearly illuminated in the hours of darkness, security-gated and fenced. Vegetation and shrubbery on the site which obscures visibility should be removed.

For a repository that forms part of a larger building, a security hierarchy should be put in place taking account of all users such as staff, visitors, cleaning and maintenance workers.

5.2.3 Protection against intruders

The repository should be secure against theft, burglary, vandalism, terrorism and other criminal acts and an intruder alarm system linked to the police or an alarm monitoring centre should be provided. It is essential that the repository is protected against intruders, whether the building is open or closed to the public or during emergency evacuation.

External intruder alarm systems should conform to BS 4737-4.3.

Advice should be sought from a security specialist regarding the installation of internal intruder alarm systems.

NOTE 1 See PD 6662 and BS EN 50131-1 for further information regarding intruder and alarm systems.

NOTE 2 CCTV systems can be used to provide additional security. Further information can be found in BS 8418.

5.2.4 Entrances

Means of access to a repository, such as doors, lifts, stairways, windows and ventilation risers, should be designed to exclude the possibility of entry by unauthorized persons and to ensure that even normal maintenance staff for the building can enter only under supervision. No part of the building in which archival material is permanently or temporarily stored should be used as a corridor or emergency exit. There should preferably be only one entrance for visitors to a building in which a repository is situated.

5.2.5 Services

To minimize unnecessary access to the repository, it should be possible to isolate and independently control services directly related to it. Wherever practicable, air-conditioning plant, heating, electricity, water supplies or drainage, including rainwater pipes, should be situated outside the repository and should be accessible without entering the repository. However, where this cannot be avoided, these services should be controllable from outside the repository. Other services, for example gas, oil, water supplies and drainage (including water pipes and sewage), should not pass through the repository.

5.2.6 Windows

Wherever practicable, a repository should not have windows.

Where windows are present in historic or existing buildings, in the interests of security these windows should be small, unopenable, barred and glazed with security glass in accordance with BS EN 1627. One-way glass may be used, where necessary, to prevent people looking into the repository.

Roof lights should never be installed in a repository.

*NOTE See **6.6** for protection against damage by pests and **5.2.4** for entrances. For more information on windows, see **6.12.6** and **6.13.1**.*

5.2.7 Doors to the repository

Doors, frames, mountings and hardware should be constructed to resist unauthorized entry. The resistance class should be established based on a risk assessment, which should take into account the value of archival documents in the collection. The resistance class for new repositories should be a minimum of RC4, in accordance with BS EN 1627. Locks should open from the inside without a key.

The fire and rescue service and any appointed security specialists should be informed about the types of locks used and their system of operation, particularly in the case of electronic or electromagnetic locking devices.

No door of the repository should be used as an external door of the building or open into any part of the building to which the public has normal access. Emergency exit doors should be designed to open only from the inside and should open onto an escape route.

*NOTE See **6.3.4** regarding environmental equilibrium, **6.4.2** regarding fire doors and fire resistance and **5.2.4** regarding entrances.*

5.3 Size

The storage repository site or, in the case of a conversion, the building, should be large enough to accommodate a repository to meet current and projected storage requirements for a minimum of 20 years from the date of occupation. Wherever practicable, there should be space for subsequent extension.

NOTE Archives continue to accrue and new buildings encourage more deposits and an increasing number of visitors. It is therefore wise to plan for the growth of archival holdings and for an increased number of readers over that period. If new buildings reach their storage capacity within only a year or two of occupancy, it can be difficult to get support from the governing body for further substantial capital development.

5.4 Self-containment

The repository and associated rooms provided for the processing, conservation, study and exhibition of documents and for administrative work and repository staff should preferably be in a detached, purpose-built building or, if they form part of a larger building, in a self-contained unit separated from the remainder of the building by a fire-resisting construction.

Where a self-contained unit is selected, any additional risks imposed by the larger building should be reviewed and mitigated as much as possible, so that the repository's security and protection are not compromised. It is essential that the risk to the repository from the larger building is also assessed. This will particularly relate to fire and structural collapse.

NOTE The security of a self-contained unit might require a tighter regime to control risks than a free-standing repository and direct input by repository staff to the control and management of the larger building to minimize risks generated within that area.

6 Repository construction

6.1 General

Clause **6** covers the recommendations for the construction of a purpose-built new repository. Individual recommendations within Clause **6** can also be used as a guide when creating an archive repository within an existing building, but it should be recognized that the original structure might not be sufficient to achieve the environmental or other protective recommendations in this document. Protected historic buildings might not be permitted to be converted into use as archive repositories.

Where period structures already house archival material, such as historic archives or libraries, a detailed risk assessment should be carried out to determine their capacity to provide a protective environment. Archives integral to an historic interior should remain in situ unless the environment has become damaging to the archives (e.g. where a local water table has risen, causing water to penetrate). Any measures taken to improve environment, security and fire protection in historic locations might need to have a minimum impact on the fabric of the structure and interior, while a separate repository or vault might need to be created within or nearby in order to house highly valuable or significant documents, especially those which are itemized by insurers or indemnifiers for special protection. A decision to move documents or archives out of their historic context should only be taken after monitoring any evidence of active damage occurring to the archival materials that cannot be remedied by measures such as packaging or permitted structural improvements.

Expert advice should be sought from appropriately experienced building design professionals when the design or re-design of a repository is planned. The fire and rescue service and police authority should also be consulted to prevent conflict between security and fire protection measures and the safety measures for both people and archives. The different parties involved with security and protection might have different priorities and it is essential that discussions take place at the outset of the repository construction.

6.2 Whole-life costing (WLC)

As archival material is to be preserved permanently, repositories are normally expected to have a long life. Whether considering a new building or the refurbishment of an existing building, in addition to the capital cost, the long-term (whole-life) operational cost in terms of energy consumption, water consumption, maintenance and periodic replacement of plant should be taken into account.

*COMMENTARY ON **6.2***

The long-term sustainability of the building and its operations can be jeopardized by inadequate thinking at the outset, not only about long-term costs but also about long-term savings, for example in energy and maintenance costs, which can necessitate greater initial capital expenditure or an alternative approach to the building's design and construction. This introduces the concept of whole-life costing (WLC).

WLC is a set of techniques that makes it practicable to assess the cost of acquiring and operating a building throughout its intended life span, including its ultimate demolition and the site and infrastructure clearance. It can also play a part in the evaluation of the environmental impact of the building.

The main use of WLC is to inform the design and investment decisions that are made at an early stage of the construction process. There are alternative strategies for implementing any set of solutions. Each strategy might have different construction and operating costs. WLC techniques provide a way of comparing all the alternative costs associated with the project. Informed decisions can then be made.

WLC also provides information for finance and budgeting.

In addition, WLC has an environmental aspect. It can be used as a tool for assessing the real environmental costs, particularly energy usage and carbon emissions. Such environmental costs could be subject to increasing financial penalties in the future, as the government seeks to address the causes and effects of climate change. WLC therefore offers a systematic approach and an explicit way of assessing these costs. It helps to identify the most effective use of resources to meet the relevant needs.

Further guidance on the service life of the building can be found in BS ISO 15686-1.

6.3 Promotion of environmental stability

6.3.1 Thermal stability

The construction should be of sufficient density and have air infiltration rates low enough for the temperature and RH to remain stable and within the recommended ranges given in **4.2** for a minimum of 24 hours in the event of exceptional weather conditions or the failure of environmental control equipment.

*COMMENTARY ON **6.3.1***

High thermal inertia is recommended irrespective of whether natural means or air-conditioning is used in the construction to achieve environmental stability.

The thermal performance of buildings, taking into account the continuous changes in outside weather conditions and uncontrolled internal conditions, can be assessed with reasonable accuracy using dynamic thermal modelling software. This software uses real weather data and takes into account the position of the sun and solar shading, together with the thermal properties of the building materials and, to a point, the contents of the building. It also takes into account the increased heat from occupants, lighting and other equipment being used in the building. Until recently, most cooling (and heating) load calculations used steady-state conditions: that is, they did not take into account the varying weather conditions and the thermal inertia of the fabric. This resulted in the oversizing of plant, inefficiency in use and increased maintenance costs. Dynamic thermal modelling software can be used to determine more accurately plant loads in both summer and winter, thereby eliminating some of these problems. However, as with most calculation tools, it needs to be used by experienced designers and the software is only as accurate as the data input which needs to include local and regional data on climate and environment. If, for example, the archivist or librarian advises the designer that the repository is only infrequently accessed, but leaves the lights on all day and regularly opens the door, the results from the dynamic thermal modelling software are likely to be inaccurate.

6.3.2 Reducing air infiltration

For quality construction and to prevent uncontrolled air changes, a new repository should be built to an air infiltration rate not exceeding two air changes per day. A repository in an older building should preferably meet the same standard but in any case should have an air infiltration rate not exceeding four air changes per day.

*COMMENTARY ON **6.3.2***

There is both controlled and uncontrolled intake of air into any building. Uncontrolled air infiltration needs to be kept as low as practicable, whether or not air-conditioning is employed. The infiltration of outside air into the building can make the control of internal conditions more difficult, and can increase the energy consumption of heating, ventilation and air conditioning systems.

Infiltration can occur through poorly sealed window and door openings, at the joints between different elements of the envelope (for example, wall and roof, wall and door, wall and window frame), and through permeable elements of the envelope such as masonry. The amount of infiltration depends upon the air pressure difference between the inside and outside of the building, mainly in response to the prevailing wind conditions. Mechanical ventilation and air-conditioning systems can also create pressure differentials. A small positive pressure inside the building is desirable, as it reduces air infiltration.

On completion of the building, the airtightness can be measured by pressurizing the building and measuring the air flow rate through a fan, or by using a tracer gas technique and measuring the decay time of the gas, or by using a mobile test rig. This is advisable for all repositories, whether in a standalone building or within a larger building. At the time of publication, this test is additional to the requirements of the Building Regulations [4] air pressure test. Doors and openings need have no additional seals applied for this test. See the Air Tightness Testing and Measurement Association document, Technical Standard L2: Measuring air permeability of building envelopes (non-dwellings) *[12] regarding air pressure testing. It might be advisable to seek specialist advice for these measuring techniques where necessary.*

The quality of uncontrolled air intake cannot be guaranteed. If the external air is polluted (the relevant local environmental health department can advise), pollutants that are not absorbed by the fabric or deposited on the surfaces can harm the archival materials. Monitoring of the internal air quality is desirable.

Specific attention is drawn to the Building Regulations [4].

6.3.3 Materials

Walls, floors and ceilings inside the repository should be made of a material such as dust-sealed concrete block or unfired brick, or from combinations of materials that have a high thermal and hygroscopic capacity, with insulation materials appropriate to the system of construction selected. Internal finishes should not impede the function of the thermal and hygroscopic capacity of the building to stabilize conditions.

Building materials and finishes used should not have any negative impacts on the internal storage environment. For example, materials which might off-gas over time should not be used.

NOTE See PAS 198 for information regarding the damage to collections caused by materials that produce pollutants.

6.3.4 Environmental equilibrium

Expert advice should be sought about the best means of enclosing the repository to assist in the establishment of environmental equilibrium. An enclosed space, with a door at either end, should be provided between compartments having different environments.

Where two repositories are connected, or a repository links directly to another room or corridor that is not maintained at the same environmental conditions, it can be prudent to introduce an airlock. The airlock has an electrical interlock that prevents one door from being opened before the other has been closed. The layout of the airlock should allow for the movement of staff and documents.

6.3.5 Building acclimatization

In the case of newly constructed buildings, time should be incorporated in the construction schedule to allow the building to dry out and to enable its internal environment to stabilize before any documents are stored there. These drying times should not be shortened or omitted in the event of construction delays and should be incorporated into the project schedule. The environment inside the building should be monitored during this drying period and only when stable conditions are achieved should archival materials begin to be introduced.

*COMMENTARY ON **6.3.5***

The time necessary for a building to dry out and for its internal environment to stabilize varies from building to building. It is dependent on the form of construction (i.e. wet or dry) and the building materials that are used. Each building project therefore needs to be assessed individually to establish its appropriate drying time. The dryness of a building can be assessed by monitoring the RH and temperature of the building.

Where two or more diverse forms of construction are to be used in an archive or library building, it is particularly important that the construction schedule takes drying times into consideration. A wet form of construction, of high thermal inertia, (for example, cast in-situ concrete floors, masonry walls) takes longer to dry out than, for example, a lightweight prefabricated dry form of construction that might be used for public and staff facilities.

Transfer of archives to a new repository can impact on the environmental conditions and in such instances a further acclimatization period is necessary. This will have a short-term negative effect on the performance of any air-conditioning plant. Movement of archival materials creates dust. Therefore it is important to check the condition of ductwork, filters and other equipment.

6.4 Structural fire protection and compartmentation

6.4.1 General

Fire precautions, including limitations on distance of travel for means of escape, are the subject of national legislation which may be supplemented in some areas of the country by local legislation. Fire precautions should be discussed with the fire and rescue service and fire insurers. Experts such as fire engineers, fire consultants and insurers should be asked to advise about particular problems.

Archival materials can be highly susceptible to damage or outright destruction in the event of fire; therefore, it is essential to consider the risks at each of the following stages:

a) construction and planning of the building;

b) equipping the building; and

c) management of the building.

*COMMENTARY ON **6.4.1***

*The aim is not only to minimize the possibility of a fire breaking out within the repository itself, but also to make the storage area as impregnable by fire as is practicable in the much more likely event of a fire originating in areas adjacent to, above or (in a building of several storeys) beneath the repository. For this reason, it is recommended to carry out an overall fire risk assessment at the design stage (see **7.2**).*

Guidance on insurer's recommendations can be found in The design guide for the fire protection of buildings *[13].*

6.4.2 Fire resistance

The elements of structure of the repository should be designed to provide four hours of fire resistance against a fire occurring either inside the repository, in any adjacent compartment of the building or from sources outside the building.

Fire risk assessments should cover adjacent premises (e.g. shared buildings or neighbouring buildings with a party wall) to assess conformity with the four hour fire resistance recommendation.

It is recommended that for new builds or conversions, no repository wall, floor or ceiling should form part of a party wall, floor or ceiling.

*COMMENTARY ON **6.4.2***

BS 476 can be used for testing materials for fire resistance.

*See **7.2** for fire risk assessment.*

Fire resistance for four hours is a demanding recommendation and there are substantial cost implications in complying with it. However, it reflects the unique and irreplaceable nature of archives and certain library materials, and the necessity to protect these. Compliance is practicable and has been achieved in a number of recently built repositories.

The geographical location of the building needs to be taken into account, together with the call-out time of the fire and rescue service at any time of the day or night. Some caution is needed over the latter consideration, as the distribution of fire stations can change. The accessibility of the repository to the emergency services is another important consideration. This involves not only the ability to get fire-fighting equipment to the centre of a fire, but also the ability of the fire and rescue service to reach the site in the first place. This is especially important if the repository site is remote or accessible only through dense traffic or narrow streets or if the repository is self-contained (i.e. not a part of a shared building) and equipped with an automatic fire-detection, alarm and suppression system. In determining whether the fire protection is sufficient in each case, the inspecting bodies generally take into account all of the fire prevention measures implemented.

Doors offering only two hours of fire protection installed in walls that offer four hours of protection only allow for two hours of fire protection to the contents. In order to be effective, four hour fire resistance needs to apply to the whole structure around the storage area; that is to say, above and below as well as at the sides. If the archive or library storage area is in a building where a fire below or adjacent could weaken the structure of the building enough to make it collapse, it is advisable to find another storage location, even if the building is constructed to the four hour fire resistance recommendation.

6.4.3 Compartments

For reasons of fire safety and/or environmental control, the repository may be divided into compartments with the advice of relevant experts. Internal/external walls, floors, ceilings and doors between single rooms and compartments and between storage and other areas of the building should be constructed such that fire (and water and smoke) is prevented from spreading into a neighbouring unit. The fire resistance of compartments should conform to **6.4.2**.

*COMMENTARY ON **6.4.3***

*Fire compartmentation can have an impact on the archive storage environment. See **4.5** for environmental monitoring.*

Compartmentation of the archive storage space can assist in fire control, but can be unnecessary, depending on the size of the storage area and on the overall fire-prevention strategy adopted. It can also add to logistical problems in archive storage. For these reasons, the maximum area for a compartment is not recommended. It is important to consider the desirability and necessity of compartmentation as part of the overall design and protection strategy, as well as the size that the compartments need to be.

6.4.4 Doors and other openings

Openings, including ducting, in fire-resisting walls should be protected to prevent the movement of smoke and be fire resistant to the same level as the walls that contain them. Doors should be self-closing in the event of a fire.

*NOTE See **5.2.7** on the security of doors, **6.7** on the avoidance of door sills and **7.4.4** regarding fire dampers in air conditioning systems.*

6.4.5 Vertical openings

Stairways, lift shafts, ventilation risers and other vertical openings that might act as flues for fire, smoke or toxic gases should be enclosed by walls, partitions or dampers and doors of material with an appropriate fire resistance (see **6.4.2**).

6.5 Protection against water

6.5.1 Design and materials

Archives should not be placed in repositories where moisture is penetrating through the walls, floor, ceiling or openings. The building should be designed and the materials for its construction chosen so the risk of damage to the documents from water, whether in the repository or any other part of the building, is eliminated.

Intermediate floors in multi-storey repositories should be waterproofed. The ingress of water should be prevented at the junction of different construction materials, elements and at all corners.

Where circumstances dictate the use of basement accommodation, it is advisable to use the accepted and traditional forms of waterproofing such as construction of a bund to prevent the ingress of water.

Stand-alone dehumidification equipment should not be used as a permanent solution. All dehumidification equipment should be efficiently drained. Where dehumidification equipment is necessary to stabilize an environment, for example after a flood, the equipment should drain outside the storage area and should be regularly monitored.

NOTE 1 Water might be present due to rain, snow or flooding, blocked gutters, leaking or burst pipes, condensation, ground water or from water used internally to extinguish a fire.

*NOTE 2 For recommendations regarding damp arising from the building process itself, see **6.3.5**.*

6.5.2 Rainwater discharge systems

Rainwater discharge systems should be designed to Category 4 design rainfall rates in accordance with BS EN 12056-3:2000, **NB.2**. The design should include a provision for sufficient weir overflows to prevent water entering a repository building when an outlet is blocked.

6.5.3 Drainage and pipework

New repositories should not be built with external drainage running though them. However, provision should be made for the controlled rapid egress of any water that might accumulate in the repository during fire-fighting or sprinkler operation, for example. Drains should be fitted with one-way valves to prevent water backing-up into the repository and should be carefully designed and sited, and regularly monitored to check that there is no risk of flooding or that they provide a means of entry for foul air or pests. It is particularly advisable to consider installing an emergency pumping system, either as an alternative or as a supplement to drains.

Existing drainage access points, pipework or other sources of water within repositories should be regularly monitored and fitted with flood sensors and alarms which are audible outside the repository.

Obstructions to the dispersal of floodwater via drains inside the storage areas or in adjacent corridors should be minimized. The lowest level of storage compartment should be at least 150 mm from the floor.

NOTE Flood water might be swept towards a drain located, for example, in a corridor adjacent to the storage area, where drainage channels can be installed. This is only fully effective if the door to the storage area has no sill. However, it is also important to bear in mind that in the event of fire-fighting, water is likely to accumulate in the corridor itself. It is therefore necessary to drain (or pump) this water away from the archives, in order to prevent it from seeping under the repository door.

6.6 Prevention of infestation by pests

*NOTE See **4.4** on the avoidance of mould and insect infestation within documents. Guidance on the prevention and treatment of pest infestations is provided in BS 4971, in* Integrated pest management *[14] and in* Insect pests in archives: detection, monitoring and control *[15].*

The exterior of the building should be kept free of vegetation. Cracks and holes in existing structures should be sealed to prevent insects migrating into the building.

The points at which any wiring or trunking enters and leaves the repository should be sealed against vermin and insects, as well as against air infiltration and dust.

Ventilation or air-conditioning supplies and extract ducts should be fitted with filters or screens to prevent the entry of pests into the repository. Doors should be installed and sealed tightly in their frames.

6.7 Floors

Floors should be level and uninterrupted by steps, door sills, heating grilles or mats in order to allow the easy passage of trolleys. Where a change in floor level is unavoidable, ramps with a maximum gradient of 8% should be provided. A high degree of accuracy is necessary for floor loads where mobile shelving is to be installed. False floors should be avoided.

*NOTE 1 See **6.12.5.1** for construction recommendations for mobile shelving.*

NOTE 2 Attention is drawn to Part M of the Building Regulations [4].

6.8 Galleries

Wherever practicable, elevated galleries should not be added to existing repositories or incorporated in new repository buildings.

Where the use of such galleries is unavoidable, the following recommendations apply.

a) Straight-flight stairs only should be provided to give access to galleries; spiral stairs should not be incorporated.

b) Gangways and stairs should be wide enough to allow the largest documents stored to be removed and replaced without difficulty.

c) Storage areas, entrances and exits in galleries should be visible from lower levels in the repository.

d) Galleries should be constructed from materials of limited combustibility.

NOTE Attention is drawn to the Building Regulations Approved Document B [16].

6.9 Ceilings and soffits

It is recommended that false ceilings are avoided as they create voids that might harbour hazards to the repository. Where the use of false ceilings is unavoidable, they should be constructed of materials of limited combustibility.

NOTE Attention is drawn to the Building Regulations Approved Document B [16].

The minimum internal height of the repository should take account of the racking height and the service zones above. The structure above the repository, including intermediate floors, should be impervious to water.

6.10 Storage space arrangement

The shape, dimensions and layout of the repository should be determined by the need to provide maximum storage space and ease of withdrawal and replacement of documents. Wherever practicable, areas should be free from obstructions to allow the best possible use of the space, especially if high-density mobile shelving and plan chests are to be used.

For new constructions it is recommended that the structural solution, in particular the column grid, should allow for the most efficient shelving layout.

Openings of doors through which loaded trolleys are to pass should be not less than 900 mm wide. Space around doorways should allow for manoeuvring trolleys and the largest objects expected to be kept in the archive, such as maps.

6.11 Load distribution

Where the use of mobile shelving is considered, an assessment regarding its suitability should be made by a structural engineer in conjunction with the shelving manufacturer.

The mass and distribution of the documents which might be stored and of the static or mobile shelving should be calculated. As a minimum, the design should conform to the imposed loads given in BS EN 1991-1-1. However, the following values are recommended for uniformly distributed loads based on a storage height of up to 2.3 m:

- *Static shelving*: 4.0 kPa per metre of height having a minimum of 12 kPa;
- *Mobile shelving*: 4.8 kPa per metre of height having a minimum of 15 kPa.

In all cases the floor is likely to be subjected to localized (point) loads either directly from the shelving uprights or from the load wheels used for mobile carriages. In addition to the uniformly distributed load, the floor should be checked for point load effects.

The following point loads are recommended:

- *Static shelving*: 2.6 kPa per metre of height having a minimum of 7 kPa;
- *Mobile shelving*: 3.0 kPa per metre of height having a minimum of 10 kPa.

Large documents (i.e. greater than approximately A1 size) might require higher kPa values than those given in **6.11**.

NOTE 1 Point load effects are particularly important when a suspended concrete floor is considered.

NOTE 2 Wet loads, for example in the event of a fire or flood, exert considerably greater force than dry loads. It is expected that such a situation will be short term and may be considered as an accidental load case. It is possible to consider wet loads as a long-term load situation; however, this will lead to a more expensive design for the storage equipment and, possibly also, for the building.

NOTE 3 The Building Regulations Approved Document A [18] recommends conformity of shelving to BS EN 1991-1-1. However, it is important to be aware that this recommendation is not always adequate for the purpose of storing archival materials.

6.12 Shelving

6.12.1 Shelf planning

Shelving should be planned to meet the needs of the particular repository. It should provide safe and effective storage for documents, whatever their size and shape, combined with ease of withdrawal and replacement. Documents should not protrude beyond the outer edge of the shelves. In positioning the shelving, care should be taken to allow for human or mechanical access to all parts of the floor and to shelving for cleaning purposes, as the accumulation of dust can prove harmful to the documents or to those who work in the repository.

The short-term and long-term behaviour of the floor slab/sub-structure should be taken into account at the planning stage in assessing the suitability of the floor to support the storage equipment and carry the dead and imposed loading.

*COMMENTARY ON **6.12.1***

Archival loads are generally in place for many years and it is therefore important that the long-term behaviour of the building is considered. Suspended concrete and timber floors experience long-term deflections (creep) that might exceed the initial floor deflection. This means that a floor that was initially acceptable might become unacceptable over time. This is undesirable and can be a particular problem if mobile storage is adopted.

For the purpose of initial planning, the dimension measured from the centre of one upright to the centre of the next, may be taken as 1 m. However, the actual dimension will vary depending upon the shelving system chosen or the measured size of the archival material.

6.12.2 Basic recommendations for shelving

Repository shelving, whether static or mobile, should:

a) be strong enough to carry the potential load;

b) be of a material that is durable and that does not emit substances harmful to archival materials in ordinary use or in the event of fire;

c) be easily adjustable, without mechanical aids, to accommodate units of varying size and shape and permit the arrangement of documents in relation to each other;

NOTE It is inadvisable to store items or containers so tightly on shelves that they cannot be removed easily.

d) not have features or properties damaging to documents or people, for example: sharp angles, projections, chemical composition;

e) include an unperforated top cover to prevent dust and debris falling onto the contents;

f) permit free circulation of air and, in particular, not be positioned against an outside wall;

g) have provision for labelling each run, bay and shelf.

It is essential that the gap between a run of static shelving and a parallel wall is accessible for cleaning and a minimum gap of 530 mm in width is recommended.

*COMMENTARY ON **6.12.2***

*Refer to Approved Document B [16], Part 1 for guidance on the Building Regulations, **6.13.4** for guidance regarding light levels for the storage and retrieval of documents, **6.11** regarding load distribution and **4.6.2** regarding ventilation.*

*There is no recommendation for the use of either wood or metal for shelving in archives and libraries as they both have advantages and disadvantages. However, general recommendations are given for the attributes of shelving. Specific recommendations for metal shelving are given in **6.12.3**, but this is not intended to rule out the choice of wooden shelving. It is important that material selection for shelving is discussed with suppliers.*

Wooden shelving is often dismissed as a fire hazard due to its flammability. However, if wooden shelves are thick enough and a fire occurs, the wood is likely to smoulder for a long time before igniting. If there is a swift response to the alarm, the shelving will probably remain intact. There is also concern that certain woods can give out acids harmful to the stored materials, and that they might attract some insect pests, even in the normal storage environment. This problem can be avoided by careful selection of the type of wood and a pest management programme. The same constraint applies to wood used in exhibition cases.

6.12.3 Metal shelving

Components should be free from burrs, rust, sharp edges, scale and grease. Steel shelving should be manufactured from material conforming to BS 1449-1 as a minimum. Where steels of a higher grade are used, confirmation of their incorporation and their specification should be obtained from the supplier. The use of other metals is not prohibited.

Uprights and shelves should be finished with a protective coating to prevent corrosion in the repository environment. The coating used should be inert.

NOTE Although metal shelving is non-combustible, it can buckle and collapse in the heat of a fire, dropping its contents on to the floor.

6.12.4 Shelves

6.12.4.1 General

Shelves should be of a size and shape that fully supports the archival materials that they are intended to hold, while leaving sufficient space for the contents to be easily and safely withdrawn or replaced.

Excessive shelf deflection can potentially damage archives, either by causing stress to documents stored on a deflecting shelf or by a deflecting shelf above stored documents crushing them. Large volumes are especially vulnerable: when the shelf deflects on its long edge, the bottom of the volume can splay while its top is compressed by other volumes. When shelves are being selected, the maximum permissible deflection (the deflection limit) for the shelves, based on the weights and actual loading conditions expected should be agreed by the person responsible for the archive and the specialist shelving supplier.

Where no deflection limit is specified, the maximum permissible edge deflection of any metal shelf should be defined as SPAN/200, i.e. calculated by dividing the shelf length by 200. For example, the maximum permissible deflection of the long edge of a 1 000 mm shelf would be 5 mm (1 000/200).

The minimum distance from the floor to the top of the bottom shelf should be 150 mm in order to prevent damage occurring to the stored documents from pedestrian or trolley traffic, or from water in the event of fire-fighting or flood.

6.12.4.2 Uprights

The uprights should be strong enough to support the bay load, and the shelf-clips or bearers should be strong enough to support the loading capacity of a shelf.

The uprights and shelf-bearers should not obstruct the withdrawal or replacement of documents or their containers.

Open-sided uprights should be used to allow the free circulation of air.

In areas where volumes are being stored, perforated uprights are allowed. The design of the upright should be such that books and documents cannot become trapped or damaged.

6.12.4.3 Access

Generally, the shelves and their contents should be accessible and within reach of a person standing on the floor (or integral floor on a multi-tier system). However, if this does not allow for easy access to the archives, then free standing access steps or a personnel lifting device may be used.

NOTE Attention is drawn to the Work at Height Regulations [5].

6.12.4.4 Bracing

Cross-bracing in the bays of double-sided runs should be kept to a minimum in order to allow through-storage of large documents.

6.12.5 Mobile shelving

6.12.5.1 Construction

Mobile shelving should be installed only on track supported on level floors. To prevent the spread of dust, concrete floor surfaces should be sealed where mobile shelving is to be used. Mobile shelving should not be installed directly on compressible floor coverings. To assist with air circulation, there should be a gap of not less than 25 mm between units.

The deflection of the floor due to imposed loads should not exceed 1:1 000. This should be calculated to take into account both short- and long-term deflections. It is recommended that this calculation is carried out in the initial design of the floor structure.

*COMMENTARY ON **6.12.5.1***

*Mobile shelving saves space, but needs greater floor loading capacity and level floors. Some repositories in the United Kingdom have had problems with floors that have deflected. This causes the mobiles to roll down the slope which presents a possible safety issue to the users of the system. It is difficult, disruptive and expensive to rectify deflected floors. See **6.7**.*

One technique that can help to prevent deflections exceeding 1:1 000 can include the introduction of a secondary steelwork grid that supports the mobile tracks that can be periodically adjusted to deal with deflections during the design life of the repository. Another technique is the application of an upward deflection (pre-camber) to the rails to offset the predicted downward deflection. However, it might prove difficult to provide an acceptable solution over the complete design life of the repository.

6.12.5.2 Movement of runs

Mobile shelving should be constructed in such a way that prevents the movement of runs from damaging the documents stored in them. Documents should be housed completely within the depth of the shelving. The method and speed of operation, acceleration and braking should be such that documents do not slide and fall off the shelves.

It is not recommended that runs of mobile shelving back onto each other unless there is a clearance of a minimum of 150 mm between them. On electronically driven systems the minimum clearance should be 500 mm.

Where mobile shelving is installed as a result of capacity requirements, and the archival materials being stored are fragile, the use of an electronically operated system fitted with soft-start, soft-stop features is recommended.

Manufacturers' advice should be sought about the most suitable mobile shelving system (based on the individual requirements of the repository, pick rates, and type of storage) for each specific application. Mobile shelving systems should be operable with one hand.

Consideration should be given to the following when selecting the type of mobile shelving system.

a) *Load per carriage or chassis.* This determines the effort required to move a mobile carriage, and influences which of the drive methods is used. Operation by manually pushing or pulling a mobile to create an aisle is not recommended unless the system is a small side-to-side system where the front bay is moved to access the bay behind. This should only be permitted if the load or force required to move the mobile shelving is not greater than 100 N. Where this is likely to be exceeded, a mechanically assisted system should be considered. The mechanical assistance can be increased to reduce the effort required to move the mobile shelving. Consideration should be given of the effort involved in moving shelving when comparing mechanically assisted systems with electronically operated systems.

b) *Length of carriage.* This is dependant on the storage area of the repository and the manufacturer's limitations.

c) *Type of storage/frequency of use.* Mobile shelving systems can be used over a wide range of storage requirements, from a low to a high frequency of use.

d) *R*ails. Mobile shelving rails should be installed flush with the floor surface in order not to present any trip hazards to the users. Where it is not practicable to install recessed rails due to building constraints, a composite floor should be built up to the rail height with ramps to this floor surface kept to a minimum. Continual bumping of trolleys over rails and ramps might cause damage to the archival materials being transported.

Consideration should be given to the number of access aisles in relation to the number of users who might require simultaneous access to the shelving system. An archive whose pick rate is one retrieval per day, for example, needs fewer aisles than an archive with a pick rate of several per hour. The anticipated retrievals from, and returns to, the shelving system over a given period should also be taken into consideration.

NOTE Mobile shelving is much less suitable than static shelving for a high pick rate operation due to the necessity of creating an aisle for potentially every pick or retrieval.

A manually operated aisle safety lock should be fitted to every mobile carriage or chassis in a mechanically assisted mobile system.

Where electronically operated mobile shelving systems are implemented, the motors should be either fully encased (AC motors) or low voltage (DC motors) and the design should conform to BS EN 15095.

6.12.5.3 Stability

The stability of mechanically assisted mobile shelving is influenced by the height-to-depth ratio, speed of acceleration or deceleration as well as loading patterns.

Where the height-to-depth ratio of mobile shelving runs is such that sudden braking, acceleration or uneven loading might cause them to tip or shake, anti-tip devices should be fitted. Runs having a height-to-depth ratio of less than 5:1 may be considered stable. It is recommended that runs having a height-to-depth ratio between 5:1 and 7.5:1 are fitted with anti-tip devices. Runs with a height-to-depth ratio in excess of 7.5:1 but less than 10:1 should be specially designed for stability.

Those with a height-to-depth ratio greater than 10:1 are unstable and should not be used.

NOTE See BS EN 15095 for the stability data on powered electronic systems.

6.12.5.4 Load warning notices and shelf usage

Load warning notices that are supplied by the shelving manufacturer or shelving supplier to direct the user on how to use the shelving systems safely should be displayed adjacent to or on the mobile shelving.

NOTE See BS EN 15635 for more information.

Operation and maintenance of shelf systems should be carried out in accordance with the manufacturer's instructions at all times.

6.12.5.5 Fire control

To assist in fire control, the spines of double-sided runs may be separated by solid metal partitions placed at every five or six runs. Where an automatic fixed fire-fighting system is installed, the runs of any mobile shelving should be set apart by not less than 25 mm when the repository is unoccupied in order to assist the penetration of the fire-fighting agent to all parts of the storage equipment.

*NOTE See **6.4.3** for guidance on fire compartmentation.*

6.12.6 Arrangement of runs

The arrangement of runs should be determined by the repository's needs. To save space and increase storage capacity, unnecessary multiplication of gangways and aisles should be avoided.

Runs should be placed such that they are separated from the walls by a minimum distance of 300 mm. Where the shelving is parallel to the wall the run ideally should be mounted on a mobile carriage or chassis to allow it to be moved for cleaning behind it or, in the case of static shelving, separated from the wall by a minimum distance of 530 mm for a static shelving run. This separation facilitates air circulation as well as repository cleaning and also impedes any transmission of damp which might enter the building structure. Where direct sunlight into the repository is unavoidable, the runs should be set at right angles to windows to reduce the harmful effects of the sunlight.

NOTE Attention is drawn to the Building Regulations (Approved Document B) [16].

6.12.7 Gangways and aisles

Gangways should be not less than 1 100 mm wide. Aisles should be not less than 750 mm wide and should be wide enough (i.e. shelving depth plus 450 mm) to allow the withdrawal and replacement of documents without damage.

NOTE Attention is drawn to the Disability and Equality Act 2010 [6] and the Building Regulations [4].

6.12.8 Storage equipment and storage area for outsize documents

6.12.8.1 General

The recommendations for safety, materials, finish and ease of withdrawal and replacement of documents that apply to equipment for the storage of documents stored in standard shelving runs also apply equally to equipment for the storage of outsize documents such as maps, plans, diagrams and working drawings.

NOTE 1 Outsize documents are documents that cannot be stored on the standard runs of shelving in the repository designed for the bulk of the collection. This could be due to individual weight or dimensions.

NOTE 2 Attention is drawn to the Manual Handling Regulations 1992 [7] and guidance to the Manual Handling Regulations [17] regarding the handling of large and heavy items.

6.12.8.2 Storage area

For ease of handling, the storage area for maps, plans and drawings should be located within the repository as close to the place at which they are consulted as is practicable.

6.12.8.3 Risk of strain and distortion

Wherever practicable, storage equipment should allow maps, plans and drawings to be stored, unrolled and unfolded to avoid risk of strain or distortion. This applies in particular to maps, plans and drawings of accurate scale from which detailed measurements might have to be taken. Vertical storage is not recommended for such documents. Vertical storage is acceptable for other outsize material only under the conditions set out in **6.12.11**.

*NOTE See **6.12.12** for rolled documents.*

6.12.9 Unrolled documents – horizontal storage

Maps, plans and drawings should be stored either in shallow drawers in map-storage cabinets or on special repository-type shelving. Wherever practicable, and for reasons of practicality, drawers should not be fitted at heights greater than 1 400 mm.

The placement of plan chests is particularly important as the space required to access the archival materials needs to be at least twice the depth of the plan chest plus an additional 450 mm.

6.12.10 Cabinets

Where banks of drawers in cabinets are in use, each drawer should be fitted with an interlock to prevent more than one drawer at a time being opened. The bottom drawer should be at least 150 mm above floor level. Drawers should move along their shorter edge. They should be easy to handle and smooth-running, with bearers to support them to prevent their canting when fully open. They should be fitted with a safety stop to prevent inadvertent total drawer withdrawal, a protective flap inside the front edge and a lip of not less than 150 mm at the back. There should be provision for labelling each drawer.

6.12.11 Unrolled documents – vertical storage

Where necessary, maps, plans and drawings may be stored hanging, provided that their weight can be supported by the whole of their width. This should prevent distortion. Documents stored in this way should be mounted on guards, in accordance with BS 4971. Supports should be attached to the guards, not the documents.

6.12.12 Rolled documents

6.12.12.1 General

Vertical storage should not be used for rolled documents. Shelving used for rolled documents should conform to **6.12**. It should contain and support the entire document.

Rolled maps, plans and drawings may be stored on shelving which is accessible from both sides. They should be placed in a single row on each shelf or pair of shelves at right angles to a gangway. They should not protrude into the gangway.

Where maps, plans and drawings are too long to be stored across shelving accessible from both sides when rolled, they should be stored on specially designed shelves of a suitable depth, or lengthways on cantilevered shelving.

6.12.12.2 Cantilever shelving

Cantilever shelving consists of columns and of one or two horizontal beams at the base and at the top to provide stability. A series of arms are attached on which either a shelf is placed or the load is supported by the arms directly.

In order to prevent documents rolling off, shelves may be canted towards the rear of the bay or shelf at an angle not exceeding 10° or fitted with a rounded lip.

Cantilever shelves should also:

a) have a solid back not less than 150 mm high for the whole of their length;

b) be set with the longest side parallel to an aisle or gangway;

NOTE 1 This allows for the easy withdrawal and replacement of the archival documents.

c) have rolled or turned front edges;

d) have provision for labelling;

e) be set with at least 75 mm between the solid back and the wall, where supported on wall brackets.

NOTE 2 This allows air to circulate.

6.12.13 Outsize bound volumes

To store outsize bound volumes, shelves should be designed so that they can be stored flat, i.e. on their front or back board faces, not standing upright. The shelf should support the entire surface area of each volume; therefore the larger of two differently sized volumes should be stacked at the bottom. The shelf should be of a size that allows the spines or identifying labels (e.g. where boxed) to face outward so that volumes do not have to be turned to read their identification. Double-sided shelving should be used if outsize volumes in landscape format are stored along with volumes in portrait format.

Individual requirements with regard to shelf deflection should be discussed with the shelving supplier.

6.12.14 Cupboards and chests

Document storage in a cupboard or chest should be considered as it can provide additional security, climatic inertia and resistance against fire, water and light which otherwise might not be obtained. Cupboards or chests should not be positioned against an outside wall and should not be constructed of material which might be harmful to the documents.

NOTE It can be easier to control a microclimate within a cupboard or chest than the ambient conditions in the room. It is similar to the assistance that boxes and enclosures give for maintaining environmental stability for the documents stored within them.

Cupboards or chests should not be implemented as a means of rectifying problematic environmental conditions.

6.13 Lighting

6.13.1 General

Exposure to light can damage documents. The damage is cumulative, depending upon both the intensity of the light and the duration of the exposure, causing inks, pigments and dyes to fade, and contributing to ageing and embrittlement. The intensity, duration and spectral distribution of illumination in a repository should therefore be controlled to minimize damage. For these reasons and also in the interests of energy efficiency, lights should be switched off either manually or automatically (for example by means of a time switch or movement detectors) when not required and large storage areas should, where necessary, be divided into separate lighting zones.

When selecting artificial lighting for a repository, the following should be considered:

- the energy efficiency of the lamps;
- any potential fire risks or hot spots (see **7.3.6**);
- the heat output of the lamps and the effect on the thermal environment;
- the use of light coloured surfaces (walls, floors, ceilings) in order to maximize the ambient light levels.

NOTE Light coloured surfaces can be used to reduce the number or intensity of lamps installed in a repository.

Lighting should be fitted along the length of each aisle and gangway and at right angles to mobile shelving runs, unless integrated into the mobile shelving system.

Lighting should not obstruct access to the shelving and there should be a minimum distance of 500 mm between a lamp and the nearest unprotected archival material.

Lighting may be attached to the shelving system. For mobile shelving, lighting can be arranged to switch on and off as individual aisles are opened and closed.

Lighting should not emit UV radiation (i.e. wavelength less than 400 nm).

Direct sunlight should not enter the repository. However, in an historic or existing building where windows are present, they should use a UV filter. UV filters should be checked annually to check that the UV protection has not expired or replaced where they have.

To stabilize the environment, guard against condensation in the repository and reduce the risks of exposing documents to light, windows, where provided, should be at least double-glazed, with a UV filter incorporated in the glass or provided as a screen. In addition, shutters, louvres or blinds should be used wherever practicable.

*COMMENTARY ON **6.13.1***

*For windows, see **5.2.6**; see **4.10.4** for exhibition lighting.*

Damage to documents can result from exposure to all kinds of light, but particularly from exposure to UV radiation.

For maximum preservation of the archival materials, they would ideally never be exposed to light. However, this is not usually practicable. In some cases, microform or digitized surrogates for study purposes can be used. The originals can then remain unexposed in storage.

6.13.2 Fluorescent lamps

Where fluorescent lamps are installed in a repository, they should be of high frequency, preferably be dimmable and fitted with diffusers. The positioning and operation of lamps should be planned so that aisles, when in use by staff, are not left in shadow. Fluorescent lamps that exceed 10 μW per lumen of UV radiation according to the manufacturer's specification, should be fitted with an effective UV filter, cutting off any light having a wavelength of 400 nm or less. UV filters should be checked annually, using a UV meter and replaced when readings show levels above 10 μW per lumen.

Fluorescent lamp fittings should not obstruct access to the shelves and there should be a minimum distance of 500 mm between a lamp and the nearest unprotected document.

6.13.3 Light emitting diode (LED) lamps

Where LED lamps are installed in a repository, they should be of a type that does not emit UV radiation.

The benefits for using LED lamps are that they provide an energy efficient form of artificial lighting and can have a low impact on the thermal environment of a repository.

6.13.4 Light levels for storage and retrieval purposes

It is essential that lighting required during the retrieval and replacement of the stored materials takes into account the health and safety of the people concerned. Therefore it is inadvisable to have uncomfortably dim or unnecessarily bright light levels, i.e. less than 100 lx or more than 300 lx. The brightness is of less concern if the materials are boxed, but energy usage and temperature control need to be considered.

*NOTE In accordance with the Building Regulations [4] at the time of publication, an emergency lighting system is required, to allow people to exit in the event of a power failure (see also **6.13.5**).*

6.13.5 Installations

6.13.5.1 Electrical circuits

Switches should be placed outside the repository to isolate the electrical circuits that serve the repository.

*NOTE See **7.3.5** for master switches.*

6.13.5.2 Wiring

Wiring should conform to **7.3.4** and BS 7671.

NOTE Attention is drawn to the IEE Wiring Regulations [BS 7671].

6.13.6 Secondary lighting systems

An emergency lighting system conforming to BS 5266-1 and BS EN 1838 should be provided. A separate circuit of lighting for cleaning and maintenance is desirable.

7 Fire protection and prevention

7.1 General

Fire precautions should protect the content and structure of the repository both from the fire itself and from damage caused by fire-fighting operations, as well as protecting staff.

Most archives are made of combustible materials and therefore should be kept away from all sources of flame such as smoking or hot working. The probability of fire occurring should be reduced to the minimum level practicable by a combination of design and management.

Guidance and recommendations relating to structural fire protection are given in **6.4**.

NOTE While issues regarding repository management are outside the scope of this Published Document, it is important that repository staff are made aware of the location of fire fighting appliances and manual initiation points for gas suppression systems and are trained in their use.

Fire risk assessment and plans involving the archive collections as part of a wider disaster recovery plan should be drawn up in collaboration with the local fire and rescue service and fire insurers in order to provide the fire and rescue service with information in the case of an emergency. The fire risk assessment and plans should include a warning that the indiscriminate use of water can cause serious damage to documents.

7.2 Fire risk assessment

A fire risk assessment should be undertaken to determine the level of fire prevention and protection necessary to protect the archival materials from fire.

The assessment should be performed:

a) at the design stage of a new build;

b) at the design stage of an alteration of an existing building;

c) at any reconfiguration of a repository and its contents;

d) where changes that occur externally to the repository might increase the risk of fire.

NOTE Attention is also drawn to the Regulatory Reform (Fire Safety) Order 2005 [8].

The need for a lightning protection system should be determined in accordance with BS EN 62305. Lightning conductors should not run within the repository fire compartment.

7.3 Minimizing fire hazard in an electrical system

7.3.1 General

Electrical circuits should not pass through the repository unless they serve it.

*NOTE See **5.2.5** for recommendations on services.*

7.3.2 Installations

Electrical installations in the repository should conform to BS 7671.

7.3.3 Inspection and maintenance

The entire fixed electrical distribution system for the repository, including extensions and additions, should be maintained, thoroughly inspected, tested in accordance with BS 7671 and a written report produced at least once every five years.

NOTE Attention is drawn to the IEE Wiring Regulations [BS 7671].

7.3.4 Cable

Cable insulation should be flame retardant conforming to BS EN 60332 and be of low smoke zero halogen (LS0H) to minimize the emission of harmful fumes in the event of fire. The points at which cables enter and leave the repository or pass through intermediate walls should be fire-stopped in order to maintain the fire resistance of the walls.

7.3.5 Master switches

Except for those switches providing fire detection and protection or emergency lighting, there should be a master switch or switches outside the repository to isolate electrical circuits. The master switch should be labelled and secure against vandalism and tampering and should be fitted with a warning light to indicate when the power is on.

7.3.6 Electrical fittings

Electrical fittings should have an index protection rating of at least IP20 in accordance with BS EN 60529.

Where fluorescent lamps are fitted, the fluorescent lamp ballast units should be individually fused.

Electrical light fittings selected should not create a concentration of heat (hot spots) which might present a fire risk.

*NOTE See **6.13** regarding lighting recommendations.*

7.4 Minimizing fire hazard in any air-conditioning plant and equipment

7.4.1 Planning

Where air-conditioning is used, the plant should be installed in accordance with BS 5720 and BS 9999 and the advice of heating, ventilation and air conditioning (HVAC) engineers.

7.4.2 Other premises

Where the repository is located in a building in which other parts are air-conditioned, no air-conditioning system for the repository should at any point connect with ducts serving premises outside the repository, nor should ducts serving other premises pass through the repository.

7.4.3 Ducts

Where the repository is air-conditioned, air-conditioning ducts including insulation and lining should conform to BS 9999. They should be maintained regularly and be kept free from dust. Ductwork should be installed with fire and smoke dampers (see **7.4.4**).

7.4.4 Dampers

Fire and smoke dampers of a rating to match the compartment fire rating should be installed in accordance with BS 9999, for example, where the ductwork passes through fire-compartment walls or floors. An automatic fire detector of the smoke-sensitive type should be installed at the outlet side of the fan.

7.5 Fire detection and fire-fighting

7.5.1 General

Where practicable, automatic fire-detection, alarm and automatic fire-fighting systems should be consolidated into one continuous system that detects a fire, sounds an alarm, allows a set time for people to check whether the alarm is genuine and to leave the repository, and then sets off any automatic fire suppression system. Water-based sprinkler systems should, however, operate independently (see **7.5.5**).

7.5.2 Detection and alarm system

A category P1 automatic fire-detection and alarm system, covering all parts of the building, should be installed and maintained in accordance with BS 5839-1, which gives detailed guidance on the design, installation, inspection, testing and servicing of such systems. It is recommended that a higher sensitivity aspirating smoke detector (ASD) system, supported by an appropriate level of monitoring (see **7.5.3**), is installed. ASD systems are particularly useful for historic interiors, where sampling points and pipe runs can be concealed from view. High sensitivity point detectors may also be used and are a cost-effective alternative in small archives without high ventilation flows.

NOTE 1 Further information regarding aspirating smoke detectors can be found in BS EN 54-20 and the FIA Code of practice for design, installation, commissioning and maintenance of aspirating smoke detector (ASD) systems [19].

NOTE 2 Attention is drawn to the fact that a category P1 automatic fire-detection and alarm system is recommended, as defined in BS 5839-1, rather than a category P2 automatic fire-detection and alarm system. This is because P1 is for property protection and is therefore more stringent than P2 as it covers all parts of the building.

7.5.3 Monitoring

The central automatic fire-fighting system control panel should provide a facility to monitor all components of the system, visually display the status of the system and transmit a signal to a remote monitoring centre. Panels should be located in a convenient central location that is either continuously staffed or is at least staffed while the facility is occupied or open. Where the panel location is not the most likely fire and rescue service entry point, a supplementary or repeater panel should be provided for use by the fire and rescue service.

When using high sensitivity aspirating systems, it might be necessary to utilize two sensitivity levels, one (most sensitive) to alert staff locally and the other (set to the equivalent of a normal point smoke detector) to signal to the alarm receiving centre. This can reduce the likelihood of the fire and rescue service responding to false alarms.

NOTE See BS 5839-1 for further recommendations regarding the central fire alarm control panel.

7.5.4 Operation of alarm system

Where a fire is detected, the system should be configured to:

a) sound the fire alarm;

b) indicate the location of the fire;

c) automatically transmit an alarm to the fire and rescue service via an alarm receiving centre;

d) shut down mechanical air-handling systems and operate dampers in ducts to prevent the spread of smoke;

e) close fire shutters or doors.

7.5.5 Automatic fire-fighting systems

Automatic fire-fighting systems (also known as fixed fire-fighting systems) should be included as part of the protection of archival materials in repositories. Depending upon the type of system employed, these systems can act to suppress, control or extinguish fires, both starting within the repository and starting outside in adjacent spaces within the same building that could spread into the repository. A fire risk assessment (see **7.2**) should be undertaken before deciding which system to install. Space and infrastructure constraints, sustainability and maintenance costs should also be considered.

Fire-fighting systems are most commonly specified for the preservation of human life (in offices and shops, for example) and consequently water sprinklers are most frequently installed, since these have a long record of reliability in extinguishing fires. In archives it has been common to specify inert gas suppressant systems, including systems that maintain a permanently reduced oxygen environment (hypoxic air systems) because the release of these gases is safe for organic materials and is unlikely to cause collateral damage in areas beyond the seat of a fire or cause major clean-up expense. Guidance on the selection and use of automatic fire-fighting systems can be found in BS 5306-0.

Archival materials usually represent a significant quantity of combustible material, with the potential for a deep seated Class A fire, as defined in BS EN 2. Water sprinklers are a proven method of effectively controlling such fires and limiting the extent of fire damage but the effects of water damage should also be considered. There is a potential for water damage from inadvertent or accidental operation but it is also possible to utilize pre-action sprinkler systems to obviate this risk. However, given the added complexity and cost of such systems, care should be taken before selecting one. Guidance on the design of sprinkler systems can be found in BS EN 12845 and further guidance in relation to the actuation and control of pre-action sprinkler systems can be found in BS 7273-3.

Storage practices can affect sprinkler performance, such as the shielding effect of mobile shelving (see **6.12.5**). Particular care is needed in the design of systems used to protect repositories, with the possible need for higher design densities of water than normally employed.

There are different types of gaseous system used to protect repositories, including those using an inert gas like argon and those using halocarbon agents such as heptafluoropropane (HFC-227). These are actuated automatically by an associated aspirating smoke detection system. Guidance relating to such systems can be found in the BS EN 15004 series and further guidance in relation to the actuation and control of gaseous systems can be found in BS 7273-1.

Halocarbon agents produce broken-down products on contact with flames that can be harmful to organic materials often found in archives. It might be advisable to consider this when selecting the gaseous agents to be used in automatic fire-fighting systems. Where the repository has air conditioning ducting and an exhaust (i.e. there is not a closed control unit within the room), prompt ventilation after a gaseous discharge can be used to minimize this effect. However, in rooms that are controlled only through passive means, such rapid ventilation might not be possible.

All gaseous systems generate overpressure when discharged into a space (initially there will be both the air in the space and also gas to the same volume). Prior to procurement of a gaseous system, the structure of the repository should be assessed by a structural engineer to establish whether it is able to withstand this pressure. If overpressure vents need to be fitted, these should not compromise the thermal inertia, security and air infiltration standards of the repository. Air conditioning duct-work leading to a plant-room outside the repository can have vents included so that they act as a route for the escaping air. Inert gas systems should conform to BS EN 15004 (all parts).

Reduced oxygen (hypoxic air) systems can be installed to protect archival materials but these are not as well established as gaseous suppressant systems. When selecting such a system, care should be taken to consider the implications for the safety of those working in the repository as the required oxygen level required to reliably prevent or suppress fire development might be lower than that permitted for unrestricted access. Such systems require constant replenishment of the atmosphere in the room with nitrogen or pre-mixed, reduced oxygen air. There are, therefore, continuous energy costs associated with such systems that should be considered as part of whole-life costing (see **6.2**).

Watermist systems can be configured to act like a sprinkler system or to operate like a gaseous system. The main advantage of watermist systems over sprinkler systems is that less water is used. Such systems are less well established than sprinklers or gaseous suppressant systems (see DD 8489-1). At the time of publication, there is no test protocol for configurations of stored materials found in repositories, and the effect of mobile shelving on watermist dispersion is likely to be more pronounced than on sprinklers. Watermist systems designed to flood the whole space on activation of an aspirating smoke detection system can be more effective, but with the result that all surfaces are wetted.

Archives in repositories that use a water-based extinguishing system should be boxed for protection in the event of water discharge.

The operation of an automatic fixed fire-fighting system should be monitored both locally in the repository and remotely at an alarm receiving centre.

*NOTE Guidance given in **7.5.5** does not apply to areas adjacent to the repository. For the fire protection of areas adjacent to the repository, see **7.5.7**.*

7.5.6 Portable fire extinguishers

Portable fire extinguishers provide the opportunity for the rapid extinction of small fires; however, a risk-based approach should be used to select the extinguishing agent and to choose their placement and purpose within the building. Suitable non-aqueous and aqueous portable fire extinguishers conforming to BS EN 3 should be provided.

NOTE 1 See BS 5306-8 for further guidance on non-aqueous and aqueous portable fire extinguishers.

NOTE 2 Water-based fire extinguishers are not designed for use on fires in electrical equipment. Gas-based extinguishers can be used for this purpose.

7.5.7 Protection of areas adjacent to the repository

Where the repository is part of a larger building, fire-fighting equipment that uses water should be provided outside the repository and in accordance with the advice of the local fire and rescue service. Portable fire extinguishers should also be provided in accordance with **7.5.6**.

Repositories should be protected from surface run-off from adjacent areas.

7.5.8 Fire hydrants

Fire hydrant systems should be provided in accordance with BS 9990 and the advice of the local fire and rescue service. For existing buildings where the nearest external public fire hydrants might be a considerable distance from the envelope of the building, private fire hydrants should also be provided within the site in accordance with BS 9990.

NOTE Attention is drawn to the Approved Document B [16].

7.5.9 Smoke extraction

It is important to remove the products of combustion from a repository after a fire. Where a natural venting or mechanical smoke-extraction system is installed, it should be integrated with any fire-fighting system, and should be designed to avoid water entering the repository.

Annex A (normative) Packaging materials and applications

A.1 Types of enclosure

NOTE The following types of enclosure may be used for archival storage, as deemed suitable for the contents and recommendations given.

A.1.1 Protection of bound volumes

Enclosures should conform to BS EN ISO 9706. They should be made from calcium carbonate-buffered cellulose fibre paper or from acid-free manilla, lignin- and sulfur-free material and be of sufficient weight to support the volume. Enclosures should be cut so that the grain is parallel to the joint of the bound volume. Where the volume has no boards, boards slightly larger than the text block may be tied in place to support the text block, pending conservation treatment. The wrapping should enclose the volume completely and may be tied in place with soft cotton tape, tied so that damage to the contents is prevented.

Adhesives should conform to **A.5.2**.

A.1.2 Book box (for bound or unbound material)

A book box is a rigid construction customized to the individual needs of the contents; it can have a drop down spine or drop down front flap. Materials used for the construction of book boxes should conform to BS 4971:2002, **16.3.8**.

A book box should:

a) be designed to accommodate the exact shape of the bound volume so that it does not move when the box is moved, while allowing adequate space for any projections on the binding (e.g. bosses, chains, clasps), and providing adequate protection for any particular fragility of structure and a smooth lining material to protect fragile surfaces;

b) be designed to be strong enough to withstand a pressure of at least 20 kPa and protect the contents from damage;

c) place the closed volume under light overall pressure, particularly when enclosing parchment text-blocks and stiff-board parchment covers;

d) reveal the contents immediately when opened to encourage careful handling;

e) allow easy removal of an enclosed volume.

Boxes and cases of any design should:

i) not abrade a volume during its removal;

ii) have a method of opening and closing that is simple and clearly apparent;

iii) be labelled with information about the contents and the correct position for carrying and storage, i.e. whether flat or upright;

iv) have a lining which is smooth and inert and does not present any risk to the contents.

Books stored upright in an open-sided book box might need to contain a text-block support.

A.1.3 Phase box (mainly for storing bound volumes)

A phase box is a semi-rigid enclosure made from one or two pieces of archival folding boxboard. The board is cut and creased to the exact dimensions of its contents. Depending on the method of construction, it might be necessary to secure it by means of thread and polyethylene washers on the outside fore edge. The use of staples or wire-stitching in manufacture should be avoided, but where used they should be of non-corroding material and not come into contact with the box contents.

A.1.4 Slip case

A slip case is a rigid or semi-rigid one or two piece construction enclosing the contents and may be used for the storage of documents having rigid bindings.

A.2 Protection of loose sheets or unbound material

A.2.1 Archive storage boxes

Boxes and lids should be of acid-free board of 2 mm thickness. Lids should be easy fitting. Boxes and lids should be constructed in such a way that there are the minimum number of projecting edges that might damage the contents of the box or impede its withdrawal from, or replacement on, the shelf. Wherever practicable, staples or wire-stitching should not be used. In cases where they are used, they should be made of non-corroding material, such as stainless steel.

NOTE Further information regarding suitable acid-free board materials for storage boxes can be found on the National Archives website. [3)]

A.2.2 Portfolio (for thinner bound volumes or unbound loose materials)

A portfolio is a customized cloth covered case having top and bottom boards of the equal size but slightly larger than their contents. It might or might not have flaps attached to the rear board. Cloth ties may be on the fore edge only, or else on the fore edge, head and tail, in order to hold the contents more securely.

A.2.3 Four-flap enclosure

A four-flap enclosure is lightweight, can be made from a variety of materials, though usually paper, and may be in one or two pieces, but always with four flaps enclosing the document. The materials used should not present any risk to the document enclosed. The enclosure may be secured using cord or archive tape.

A.3 Protection of rolled material on cylinders

Cylinders for rolled documents should be constructed either of acid-free board, or of board lined with a double layer of acid-free paper conforming to BS EN ISO 9706. The length of the cylinder should be at least 100 mm longer than the width of the document rolled around it, and the thickness, strength and diameter of the cylinder should be determined by the size and weight of the document. The diameter of the cylinder should be such that it allows the document to lie flat when unrolled. The cylinder, with the document rolled around it, may be wrapped twice around with a layer of cloth which should be wide enough to overlap the edges of the cylinder and be tucked into the ends to exclude dust. This should be secured by tapes at least 25 mm wide. Linen bags and archival specification kraft paper or manilla may also be used to wrap documents stored on cylinders. Documents should not be placed inside cylinders.

[3)] The National Archives website: http://www.nationalarchives.gov.uk.

NOTE Further information regarding suitable packaging materials can be found on the National Archives website. [4)]

Consideration should also be given to using square section boxes or tubes for rolled material; ideally each box should contain only one document.

A.4 Other methods of protection

A.4.1 Fascicules

Fascicules consist of a number of folded leaves sewn together through the fold to form a single section. Fascicules may be used as a safe and efficient method for the protection and preservation of single leaf archive and library archival materials. They may also be used for slightly larger documents, such as thin pamphlets or a series of leaves where it is vital for them to remain together.

Compensation guards should be included to match the combined thickness of the archival material to be protected. These should be either narrow strips of the same paper as the fascicule sheets folded in half, or hooked guards formed by a folded sheet that is slightly wider than the finished fascicule. Guards and full-sized sheets should alternate. A cover made from a thin card or manila should be provided for each fascicule.

To obtain the best results, a narrow strip of Japanese tissue should be attached to the document with starch paste to act as a guard. Wherever practicable, it should be attached to the verso edge, and cover no textual areas.

A number of completed fascicules may be boxed together for added protection.

The advantages of using fascicules are:

- there is minimum interference to the original document;
- they provide excellent physical protection;
- each document is separated and therefore protected;
- there is no, or minimal, finger contact with documents during use; and
- extraction of documents for exhibition or reproduction is easy.

The disadvantages of using fascicules are:

- they temporarily change the original format of the document;
- they are not fully secured against theft.

A.4.2 Encapsulation

The process of encapsulation is the placement of a document, usually a single leaf, between two sheets of clear inert polyester material (see **A.5.5**) that is sealed or fastened around the edges using electromagnetic or ultrasonic welding techniques. No adhesives should be used to hold the document in place. Single sheet encapsulation is most common but several encapsulated sheets can be assembled in book form.

A document should be assessed to see if it needs to be stabilized chemically before encapsulation. Professional judgement should be exercised in this respect.

The advantages of encapsulation are as follows:

- it is a method of protection with minimum interference to the original document;
- the integrity of a document is preserved;
- it provides support for fragile and delicate documents;

[4)] The National Archives website: http://www.nationalarchives.gov.uk.

- it is a method of support that is quickly and easily reversed;
- it provides protection from abrasion and surface contact during storage and consultation; and
- it provides protection from contact with water or other contaminants in the event of a disaster.

The disadvantages of encapsulation are as follows:

- it adds weight and bulk to storage systems such as plan chest drawers;
- the study of some bibliographical features is temporarily denied;
- polyester abrades easily and so might require periodic re-encapsulation; and
- the static charges generated by polyester make it an unsuitable method for loose media.

A.4.3 Mounts

A mount is a rigid support for a document, which provides physical protection and may be used to present the document in an aesthetically pleasing manner. Typically a mount is made up of a window overlay hinged to a backing board. The document is attached to the backing board so that the window frames it. The window overlay may just cover the edges of the document or be cut slightly larger to reveal them. Mounts may be used to provide protection to documents during storage, display, handling and transportation.

The advantages of mounting documents are as follows:

- it provides a rigid support and effective physical protection;
- it is an adaptable construction, which can be designed to meet a range of requirements;
- it is effective in protecting documents with vulnerable surfaces and media;
- it improves security as documents are fixed to the mount;
- it enhances the appearance of the document;
- it provides replacement of an inappropriate housing which might be the cause of deterioration; and
- it reduces the need for physical contact during consultation.

The disadvantages of mounting documents are as follows:

- the methods of attachment to the mount normally involve physical intervention with the document; and
- it changes the way in which a document is viewed, which might be at variance with its original context, purpose or meaning.

Mount boards should:

a) for short term storage, be conservation board, comprising chemically purified wood pulp having a calcium carbonate buffer;

b) for long term storage, be museum or rag board: a fibre board containing high grade cotton fibres and cotton linters, having a calcium carbonate buffer;

c) for specialized applications (e.g. photographs), be cotton fibre board, unbuffered and sulfur free.

Other materials in contact with the document should be in accordance with the recommendations for materials employed during conservation treatment and packaging (**4.8** and **4.9**).

The mount should be constructed only from archival specification materials.

NOTE Further information regarding archival specification materials for mounts can be sought from the National Archives. [5)]

A.5 Packaging materials

A.5.1 General

Whilst in storage, archives and books can be at risk from a number of damaging agents. These can originate from the immediate environment, from the natural degradation processes of the documents themselves, or occasionally from the materials of which their storage containers are made. It is therefore important to choose appropriate packaging materials.

A.5.2 Adhesives

Adhesives used in packaging used for archival documents should be acid-free and should not degrade over time.

*COMMENTARY ON **A.5.2***

The process of adhesive degradation can produce by-products that are harmful to the stored materials. Starch adhesives, as used in the conservation of paper documents, normally remain stable and do not degrade.

Further guidance is given in BS 4971:2002, Appendix G.

A.5.3 Board

Board should be archival boxboard or board with a density of 0.8 g/cm^3 when measured in accordance with BS EN 20534. The weight of the board used should be adequate to support the document the box or enclosure contains.

Board used for packaging paper, parchment and books should have a pH value between 6.0 and 9.0 and be lignin- and sulfur-free. Boards containing molecular sieves or other types of pollutant scavenger offer significant preservation advantages.

Board used for packaging photographic material should be non-buffered 100% cotton fibre, pH 6.0, free of chloride, sulfur and lignin, and pass the photographic activity test given in BS ISO 18916.

NOTE Boards are widely employed in the storage of archives and books. They are used to build book boxes, to add rigidity to portfolios and other enclosures, and to mount single sheets and outsize materials for flat storage.

A.5.4 Cloth and paper

A.5.4.1 Background

It is important to select acid-free and inert materials for the packaging of archives and books for long-term storage that do not degrade over time.

For most purposes (except for photographs and other alkali-sensitive materials), acid-free paper and board having an alkaline buffer are acceptable. Acid free paper and board are naturally exposed to various acid-forming compounds as they age, and gradually become acidic even if they were originally made with a neutral pH. The inclusion of a 2% to 3% alkaline reserve in this packaging material provides protection against any acidic decomposition products.

[5)] The National Archives website: http://www.nationalarchives.gov.uk.

An environment having an alkaline buffer is especially important for the long-term survival of paper. As paper degrades naturally, various impurities within it (such as lignin) oxidize and produce acidic decomposition products, which increase the rate of deterioration of the paper cellulose. Acid gases and pollutants from the atmosphere (such as oxides of nitrogen and sulfur dioxide) form nitric and sulfuric acid, while others (such as ozone, a powerful oxidizing agent) also contribute to the deterioration of paper. Other damaging agents such as formaldehyde and acetic acid can be emitted by furniture or building materials, and acids also migrate from adjacent materials. Commercial products are available which, when used in storage enclosures, protect documents from the effects of these damaging agents.

Paper and paperboard can insulate enclosed materials from rapid changes in environmental conditions. Paperboard also acts as a sink, absorbing to some extent pollutant gases from the environment and those emanating from the documents themselves. Molecular sieves or other types of pollutant scavenger can be incorporated into paperboard and other packaging materials at the manufacturing stage. These substances absorb and trap other chemical species and remove them, thereby complementing the absorption characteristics of the packaging material.

In the event of a water-related disaster, paperboard boxes absorb and hold large quantities of water, and can protect the contents from becoming wet for fairly long periods of time.

Paper is used universally for archive storage in the form of folders, wallets, sleeves and as a wrapping material. Further information regarding this can be found in BS EN ISO 9706.

The packaging of photographic materials presents different challenges. These materials have complex chemical structures and are particularly susceptible to degradation through contact with unsuitable packaging materials. It is essential that paper and board used for their storage have a quality fibre composition and are processed to high standards with minimum residual chemicals. In particular, it is important that the packaging materials do not contain processing chemicals which include sulfur and sulfur compounds, because of the danger of tarnishing already mentioned. It is currently recommended that paper and board for use in the storage of photographic materials are acid-free but unbuffered. As the effect of buffered materials on photographs is still uncertain, it is possible that a buffer might adversely affect them, particularly if they are in direct contact. The photographic blueprint or cyanotype and the contemporary dye transfer processes are sensitive to an alkaline environment, where discoloration can occur. It therefore seems sensible to use unbuffered enclosures until definitive information becomes available.

NOTE *See* Standards in the Museum Care of Photographic Collections *[20] for further information regarding paper used for packaging.*

A.5.4.2 Cloth

Cloth for lining boxes should be acid-free, undyed, strong and durable.

Cloth for covering boxes should be coated with a non-migratory resinous substance, e.g. acrylic resin. The surface should be non-friable with the surface fibres fully coated. In the event that the cloth becomes wet it should not stick to adjacent documents, nor bleed colour.

A.5.4.3 Paper

Paper for packaging material in direct contact with documents should conform to BS EN ISO 9706. Paper should have a pH value between 6.0 and 9.0 and be of cellulose fibre having a calcium carbonate buffer. Papers containing molecular sieves or other types of pollutant scavenger offer significant preservation advantages.

Photographs and other alkali-sensitive materials should not be stored within buffered paper enclosures. Paper for storage of photographs should be non-buffered 100% cotton fibre, pH 6.0, free of chloride, sulfur and lignin, and pass the photographic activity test given in BS ISO 18916.

Storage materials should conform to BS ISO 18902.

A.5.5 Plastics

Plastics when used in direct contact with documents should be made of archival polyester, free of plasticizers. Because of the static energy of polyester, documents with friable surface media such as pastel and soft pencil should not be stored within polyester enclosures.

Only polyester film that is chemically inert and free from plasticizers, surface coatings, textures and patterns, dyes and other impregnated substances should be used for encapsulation. Available polyester films can have varying slip characteristics. Some low slip polyester films are very smooth and can give an unsightly appearance when two surfaces make contact.

Polyester film is available in different thicknesses, most commonly 50 µm, 75 µm and 100 µm. The choice of thickness should be based on the size and degree of support needed for the encapsulated document.

*COMMENTARY ON **A.5.5***

Further information regarding the use of plastics in the storage of photographs, see Standards in the Museum Care of Photographic Collections [20].

The use of plastics for long-term storage is now widespread. However, many commercially available plastic storage products are made of polyvinyl chloride (PVC), which is inappropriate for long-term storage. It deteriorates to form a strong acid and exudes plasticizers and other chemicals used in its manufacture. Several plastics considered safe for long-term storage are available in varying grades, but some have additives which can diminish their suitability. As the identification of plastics is difficult without chemical analytical tests, it is important to select the material used for document storage carefully.

A.5.6 Tape for fastening enclosures

Tape should be made of unbleached white linen or cotton, at least 10 mm wide.

A.5.7 Thread

Thread should be made of pure unbleached linen.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 476 (all parts), *Fire tests on building materials and structures*

BS 4783 (all parts), *Storage, transportation and maintenance of media for use in data processing and information storage*

BS 5306-0, *Fire protection installations and equipment on premises – Part 0: Guide for selection of installed systems and other fire equipment*

BS 5306-8, *Fire extinguishing installations and equipment on premises – Part 8: Selection and installation of portable fire extinguishers – Code of practice*

BS 7273-1, *Code of practice for the operation of fire protection measures – Part 1: Electrical actuation of gaseous total flooding extinguishing systems*

BS 7273-3, *Code of practice for the operation of fire protection measures – Part 3: Electrical actuation of pre-action watermist and sprinkler systems*

BS 8418:2010, *Installation and remote monitoring of detector-activated CCTV systems – Code of practice*

BS 8533, *Assessing and managing flood risk in development – Code of practice*

BS EN 2, *Classification of fires*

BS EN 54-20, *Fire detection and fire alarm systems – Part 20: Aspirating smoke detectors*

BS EN 12845, *Fixed firefighting systems – Automatic sprinkler systems – Design, installation and maintenance*

BS EN 15004 (all parts), *Fixed firefighting systems – Gas extinguishing systems*

BS EN 15635, *Steel static storage systems – Terms and definitions*

BS EN 15878:2010, *Steel static storage systems – Terms and definitions*

BS EN 50131-1, *Alarm systems – Intrusion and hold-up systems – Part 1: System requirements*

BS ISO 15686-1, *Buildings and constructed assets – Service life planning – Part 1: General principles and framework*

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