Radioactive Waste Management

WPSGD no. WPS/870/03

Geological Disposal:

Long-term Management of Information and Records: Explanatory Material and Guidance

September 2016

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Radioactive Waste Management Limited
Building 587
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UK

email: rwmdfeedback@nda.gov.uk

WASTE PACKAGE SPECIFICATION AND GUIDANCE DOCUMENTATION

LONG-TERM MANAGEMENT OF INFORMATION AND RECORDS: EXPLANATORY MATERIAL AND GUIDANCE

This document forms part of the Waste Package Specification and Guidance Documentation (WPSGD), a suite of documents prepared and issued by Radioactive Waste Management Ltd (RWM). The WPSGD is intended to provide a 'user-level' interpretation of the RWM packaging specifications, and other aspects of geological disposal, to assist UK waste packagers in the development of plans for the packaging of higher activity waste in a manner suitable for geological disposal.

Key documents in the WPSGD are the Waste Package Specifications (WPS) which define the requirements for the transport and geological disposal of waste packages manufactured using standardised designs of waste container. The WPS are based on the high level requirements for all waste packages as defined by the Generic Waste Package Specification (GWPS) and are derived from the bounding requirements for waste packages containing a specific category of waste, as defined by the relevant Generic Specification.

This document provides guidance on the development of a records management system, and the selection and care of recording media, focusing on storage regimes and risk management.

The WPSGD is subject to periodic enhancement and revision. Users are therefore advised to refer to the RWM website to confirm that they are in possession of the latest version of any documentation used.

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VERSION	**DATE**	**COMMENTS**
WPS/870/01	September 2005	Aligns with GWPS (Nirex Report N/104) as published June 2005
WPS/870/02	March 2008	Responsibility for the WPSGD passed to the NDA RWMD. Aligns with Issue 2 of GWPS (Nirex Report N/104) as published March 2007.
WPS/870/3	September 2016	Aligns to the current suite of published WPSGD and NDA guidance "Managing NDA Information", Document Number IMP06, Rev 1, January 2015

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1 Introduction

Radioactive Waste Management (RWM), a wholly owned subsidiary of the Nuclear Decommissioning Authority (NDA), has been established with the remit to implement the geological disposal option for the UK's higher activity radioactive wastes. The 2014 White Paper '*Implementing Geological Disposal*' sets out the approach to making geological disposal happen and gives RWM responsibility for the delivery of a UK Geological Disposal Facility (GDF).

As the ultimate receiver of wastes, RWM has established waste packaging standards and defined package specifications to enable the industry to condition radioactive wastes in a form that will be compatible with future transport and disposal. In this respect RWM is taking forward waste packaging standards and specifications which were originally developed by United Kingdom Nirex Ltd, which ceased trading on 1st April 2007 and whose work has been integrated into the NDA.

The primary document which defines the packaging standards and specifications for Intermediate Level Waste (ILW), and certain Low Level Wastes (LLW) not suitable for disposal in other LLW facilities is the Generic Waste Package Specification (GWPS) [1]. The GWPS is supported by the Waste Package Specification and Guidance Documentation (WPSGD), to which this particular document provides an introduction.

The WPSGD comprises a suite of documentation primarily aimed at waste packagers, its intention being to present the generic packaging standards and specifications at the user level. The WPSGD also includes explanatory material and guidance that users will find helpful when it comes to application of the specification to practical packaging projects.

For further information on the extent and the role of the WPSGD, reference should be made to the *Introduction to the Waste Package Specification and Guidance Documentation, WPS/100*[1].

As part of the process of ensuring that packaged radioactive waste is managed safely in the long-term it is important that systems exist for the management of information obtained during all periods of the management of the waste. That such information remains accessible to future generations of waste custodians is an essential prerequisite for supporting future decision-making in the management of the waste.

This document provides guidance on the development of a records management system, and the selection and care of recording media, focusing on storage regimes and risk management.

This document needs to be read in conjunction with the NDA document on managing information requirements [2], which sets out a series of requirements that custodians of the information and records are expected to consider and, where applicable, to implement measures that ensure the requirements are adequately addressed.

[1] Specific references to individual sections of the WPSGD are made in this document in *italic script,* followed by the relevant WPS number.

2 Background

As part of the process necessary to ensure for the safe long-term management of packaged radioactive waste, it is important that systems exist for the management of information sources associated with the creation, storage, conditioning and packaging of the waste. Equally important is that these information sources remain accessible to future generations of waste custodians. Access to reliable and trustworthy sources of information is an essential prerequisite for supporting future decision-making in the management of the waste.

Accordingly, RWM requires that waste packagers use reasonable endeavours to record information for each waste package that will enable subsequent assessment against the requirements for safe and cost-effective handling, transport, storage and disposal. The required information is defined in the *Waste Package Data and Information Recording Requirements, WPS/400* and explanatory material and guidance provided in *Waste Package Data and Information Recording Requirements, WPS/850.*

The structure presented in WPS/400 has been developed to recognise three different functions that the data and information may fulfil in the disposability record, separated into Classes, as follows:

- Class A – underpinning and justification; information that applies to the waste type as a whole, in particular the documents that define the origin of the waste, the packaging process, the results of a development programme, waste container manufacturing specifications, the anticipated properties of the waste package and the waste package disposability record. This information provides the basis for, and justification of, the specification documents that form Class B.
- Class B – specification; a concise statement of the precise requirements to produce a waste package that would be compliant with the obligations for storage, transport and disposal.
- Class C – compliance; information collected about the as-manufactured waste packages, primarily required to demonstrate compliance with the specifications.

In general, information required for Classes A and B is expected to be traceable, whilst Class C compliance data are expected to be recordable.

Information related to the waste and waste package will exist in many implicit and explicit forms, including conventional hard copy and electronic records. The objective of this document is to provide guidance on the nature and implementation of a records management strategy. This is achieved through the identification of the media types that may be in use now or in the future, their characteristics and longevity and the potential threats to their integrity.

A fundamental consideration when developing a records management strategy is that of the definition of the ‘minimum period’ for which the records must remain accessible and intelligible. The period for the purpose of managing waste package-related records will clearly depend on the strategy adopted for the long-term management of the waste package itself and policy decisions in this regard have still to be made. For nuclear licensed sites within the NDA estate, retention of records is governed by the NDA record retention schedule [3]; for other sites, a retention schedule based on the regulatory guidance for the conditioning and disposability of higher activity waste [4], and adopted in the GWPS as a component of the time period for waste container integrity, is recommended.

Notwithstanding this, the necessity to implement a robust waste package information management system is independent of the exact nature of the method of the long-term management of radioactive waste packages, although the minimum period may well

depend on it. If, for example, a long-term waste management option was selected that guaranteed package recovery for all time (for example, indefinite surface storage), the demands placed on the information management system could be greater as there could be a requirement to re-package or otherwise re-engineer the waste package to ensure its continued acceptability.

3 Definitions and standards

It is necessary to define a few key terms, as they are used in the rest of this document:

- *'Hard-copy records'* are defined as those on which information is recorded without conversion, and from which information can be directly obtained.
- *'Digital records'* are defined as those for which the information is converted into an electronic form that will require subsequent processing to make them accessible.
- *'Readability'* is defined as the ability to recover the recorded data from the medium.
- *'Intelligibility'* is defined as the ability to turn the recovered data into something that is meaningful to the user.
- *'Usability'* is defined as the ability to interpret the data.

The following British and International standards are relevant to the application of this guidance:

- Permanent paper – ISO9706 "Paper for Documents - Requirements for Permanence".
- Archival paper – ISO11108 "Archival Paper - Requirements for Performance and Durability".
- Requirements for permanence – ISO11798 "Permanence and Durability of Writing, Printing and Copying on Paper Requirements and Test Methods".
- Stability of microforms – BS1153 "Processing and Storage of Sioleman Colver Gelatin-type Microfilms" and ISO10602 "Processes Silver Gelatin-type Black and White Film Specifications for Stability".
- Minimum requirements for an archival storage facility – BS5454 "Recommendations for the Storage and Exhibition of Archival Documents".
- Storage of microform – ISO10214 "Filing Enclosures for Storage of Processed Photographic Materials".
- Paper enclosures for the filing and storage of microfiche – BS18911 "Photography. Processed Safety Photographic Films. Storage Practices".
- Storage practices – Optical disc media – ISO 18925 "Imaging materials"
- Storage of different types of magnetic tape and optical media – BS 4783 Storage, Transportation and Maintenance of Media for Use in Data Processing and Information Storage".
- Information and Documentation - Records Management – ISO 15489 "Information and Documentation Records Management".

4 Development of a long-term records management strategy

In the context of the long-term management of records, a contrast can be drawn between two extreme evolutionary scenarios. The first is represented by orderly and effective progress, implemented through an effective management system, in which the technology is tested and the data migrated as necessary, with accurate and appropriate metadata being separately maintained. The second scenario is represented by rapid break down of the management system, such that there is no migration or data sampling carried out, and limited or inaccurate metadata created.

The information management strategy for waste package records should be agreed and implemented prior to waste packaging operations. This will enable stakeholders to develop a clear understanding of the type and source of information required, how it is to be referenced, how responsibilities will be divided and the arrangements for routine maintenance and transfer such that accessibility is assured. The information created by waste packagers and RWM will form a sub-set of the 'GDF information' and will have to be integrated into a larger system at a later stage.

The records currently created by RWM in support of packaging proposals by waste packagers, constitute a small but important component of the entire tranche of records that would need to be made available for the design, construction, operation and post-closure management of a GDF.

A measure common to many of the risk reduction strategies is the copying of original records and maintaining them at an alternative location. If this measure was adopted, day-to-day control of these copies would need to be considered. One solution is to transfer the management of one set of information to a trusted third party (TTP). The TTP will have relevant expertise in the management of information that will enable it to implement appropriate procedures for preservation over the very long-term.

The International Atomic Energy Agency (IAEA) has also considered the need to create and maintain waste package records and have provided technical advice on the subject [5]. This contains the following advice and observations, which are considered to be of relevance to the United Kingdom:

- *"The main goal of long-term maintenance of information for repositories for radioactive waste is to provide sufficient information for future generations to make informed decisions about intentional actions and assess the consequences;*
- *Since societies may change, some information may be subject to different interpretations. Therefore the information must be clear, concise and unambiguous. Where necessary a glossary should be preserved to assist with interpretation;*
- *The preservation of necessary information for the duration of the active post-closure control phase and beyond requires the establishment and maintenance of a RMS [Records Management System];*
- *Redundancy and diversity in the RMS are necessary for longevity, accessibility and intelligibility of the information.*

The primary focus of an RMS is the preservation of necessary information for the duration of the active institutional control phase, and where necessary beyond. The information may exist in many media forms. Issues that need to be addressed through a system of documented instructions, procedures and plans, to ensure the integrity of the information to be preserved, must include:

- *identification of records to be included in the RMS;*

- *record indexing and retrievability;*
- *record retention classification;*
- *record form;*
- *transmittal, receipt and acceptability of records;*
- *protection of records from adverse environments;*
- *access control;*
- *control of modification of records; and*
- *periodic reproduction or transfer between record forms, national and international archives requirements."*

This statement recognises that any system implemented would have to meet the varying needs of different media. This is likely to be the situation in the UK for some decades to come and, indeed, there are very strong arguments to suggest that key data should be recorded on a range of different media to reduce the threat of systematic failure. The IAEA has produced a number of guidance documents that could be consulted when developing a waste records management system [6], [7] and [8]

Due to their nature, any loss of digitally recorded data is likely to be total. Records Managers planning to introduce any form of Electronic Records Management System (ERMS) should ensure that such systems will enable access to and interpretation of the data over the very long term. Continuity of the ERMS may be compromised should it be replaced by another (potentially incompatible) system, or by none at all. The requirements for any ERMS should therefore include the provision for exporting records in formats that stand the best chance of being read in the long-term future without requiring a specific platform. It should be recognised that access information recorded in an ERMS tends to rely on continuous institutional control.

A model of an ERMS that could be considered is called 'The Reference Model for an Open Archival Information System (OAIS)'. This was originally developed by the Consultative Committee for Space Data Systems but has since been adopted by the International Standards Organisation (ISO) [9] and gives a very good overview of the full range of processes needed in an ERMS. It takes a long-term view of access, and sets out a series of generic processes, relationships and components that cover most of the essential requirements. It therefore provides a framework for independent evaluation of the completeness of any proposed system.

5 Selection and use of records media

5.1 Hard-copy records

The key candidates for hard-copy records are paper and microform.

5.1.1 Paper-based records

Paper comprises three principal components: wood-pulp, lignin and size. The wood-pulp provides the medium and, by its nature, contains cellulose materials. The lignin content of paper produced from ground or macerated wood-pulp is often very high and chemical conditioning is often necessary. Size is added to enhance the smoothness of the surface of the paper, reduce absorbency and, in some cases, add strength.

Lignin is a complex acid that attacks the wood fibres, causing the paper to darken, eventually becoming brittle and crumbly even under normal handling conditions. The effect of lignin attack is very apparent on old paper and is prevalent in poorer quality examples. In the late 1950's, work was successfully undertaken to produce 'permanent' paper that comprised a non-acidic size and which was loaded with calcium carbonate as an 'alkaline reserve'. Being an organic material, it should be noted that even 'acid-free' paper is still subject to degradation. Although 'permanent' or 'archival paper' degradation would normally be a relatively slow process, above average temperatures and humidity can cause the process to speed up.

Paper remains the most common information carrier as well as being the least vulnerable to technological development. It can survive benign neglect for long periods remaining readable generally without the need for ancillary equipment - assuming the symbolic nature of the written text continues to be intelligible. The addition of supplementary information to existing records is simple not least because it does not require the creation of a completely new record. For hand-written records, paper is the most practical medium.

Selection of media

For long-term preservation, it is important to specify that the paper used for creating primary records conforms to the current version of ISO9706 or an equivalent permanent paper standard. If the original records are to be handled on a routine basis, archival grade paper conforming to ISO11108 (with high permanence and high durability) should be used.

Papers meeting the ISO9706 standard can be recognised by a logo or by the statement, *'This paper meets the requirements of ISO9706:2000, Information and documentation - Paper for documents - Requirement for permanence'*. These papers are priced at a premium and can be 40-60% more expensive than standard office papers depending on the quantity required.

According to the scope of ISO11108, archival paper is primarily required for documents intended to be kept permanently because of their high historical interest, legal or other significant value.

Recording Techniques for Paper

Laser printing and photocopying are considered to be the most practical imaging techniques for the transfer of text onto paper media. The durability of both photocopied and laser-printed documents depends largely on the effectiveness of the adherence between the toner and the media as well as the quality of the paper used.

Adherence to the following simple recommendations will assist in the longevity of printed material:

- only copies using carbon black toner printed onto permanent or archival quality paper are considered suitable for long-term storage. Other pigments and dyes (used in inks) vary in their fastness and are therefore not recommended;
- colour photocopies and colour laser prints should not be archived as their fastness is variable;
- printing and copying machines should be regularly maintained;
- image adhesion to the paper should be tested on a routine basis;
- printing and copying facilities should be physically separated from storage areas to prevent pollution and contamination of archived records;
- records should be stored in the recommended environmental conditions.

Modern laser printers and photocopiers rely on heating the printed paper to a relatively high temperature in order to fix the toner. Consideration might have to be given to the effect this could have on the chemical and mechanical stability of the paper, although there is no current evidence that the process has a detrimental impact on long-term survivability.

Older records may contain dot-matrix printed records. The survivability and fastness of the ink is less well known although it is thought to be at least as good as laser printed records. Character definition is likely to be poor, compared to laser, so there is good reason for copying these records to ensure continued readability. Bubble-jet and ink-jet are thought to have similar characteristics to laser but their performance should be closely monitored if there is any doubt.

It is likely that there is a significant quantity of hand-written records in existence. Pen inks may fade over time and blue inks are especially susceptible to loss of quality where records are copied. Where possible, good quality black ink should be used for hand written records.

5.1.2 Microform-based records

Microforms continue to be popular media for the recording of large volumes of information and data. It has the advantage of requiring relatively simple technology to both produce and read. At the time of writing, the cost associated with the production of microform records is low.

Microform is a term used to describe the full range of microfilm products. Those in routine use are:

- Microfilm - usually 35mm or 16mm film that can be presented as strips, rolls or cassettes. Monochromatic emulsions are commonly used but colour film is also available;
- Microfiche - sheet film usually 105mm x 148mm, incorporating multiple images. Usually monochromatic but colour film is available;
- Aperture Cards - also known as image cards, consist of single 35mm film frames mounted onto cards. This format is often used for reproduction of engineering drawings.

Recording Techniques for Microform

There are three film composition types in current use: silver halide, diazo and vesicular film. For applications leading to long-term storage, silver halide film should be used as the other two are prone to fading when exposed to light. Silver halide film comprises silver salts in a gelatine emulsion on a polyester film base. Polyester is both stable and durable. Manufacturers claim a life expectancy of 500 years for some silver halide on

polyester base films, whilst silver halide on a cellulose triacetate base is said to be stable for 100 years.

Production standards are especially critical where microfilm is used as an original archive or as the replacement to an original record. Most standards and guidelines recommend that three copies be produced: a preservation master on silver halide film, a duplicating master also on silver halide film and as many reference or working copies as necessary on diazo or vesicular film. Film must be processed strictly in accordance with the manufacturer's instructions.

5.2 Digital records

Digital records include both data that is created and presented electronically and those that are subsequently digitised (for example, electronically scanned hard-copy records). Digital information storage falls into three categories: online, near-online and offline.

Online storage is used for information that is in current use and usually employs a magnetic disk on a computer or local area network. Because the information is in constant use, it is stored on devices, physically located in the computer or very close to it, that enable rapid access.

Near-online storage is used where the information is not as frequently accessed and can employ slower devices in a remoter part of the network. Access to the data is consequently slower. Near-online devices do not require any physical transfer of media and the storage device is normally fully automated to assist with the location of the required information. This approach is sometimes used as a primary back-up to important information.

Offline information is stored in a form that cannot be immediately read. Backup disks or tapes removed from a computer are an example. The 'remoteness' may vary from storage close to the computer (for example, a back-up tape) to information stored at a secure facility many miles away. It follows that offline storage is used for data that will not be accessed frequently. It usually requires human intervention to locate the media storing the information and physically transfer to a device capable of reading the data.

The convenience, potential storage capacity and, increasingly, relatively low cost, make digital media an attractive alternative records medium to paper or microform. Most organisations have computer systems that can be used to record and store information quickly and accurately. Most industrial activities employ computer systems and it is perfectly sensible to use these systems to capture information, to collate it in a convenient form and store it for future use. It is not surprising, therefore, that digital records are commonly used in waste packaging operations. There are three key candidate digital media types: magnetic, optical and solid state.

5.2.1 Data recorded on magnetic media

For convenience 'magnetic media' has been sub-divided into two types: disk and tape.

Magnetic disks are the principal media for online storage used on contemporary computer systems. Most high capacity disks are fixed within the computer whilst lower capacity removable disks are used for the transfer of relatively small quantities of data. Modern magnetic disk technology is highly reliable and offers high performance, although it is generally considered to be an expensive way to store large volumes of data for which there is no requirement to alter or amend. Magnetic disks are not generally used as an archival medium, where the data may be needed only occasionally, as high capacity removable disks are relatively expensive due to their complex design, although costs are reducing. The use of a hierarchical storage system (based on online, near-online and offline storage) can further reduce the cost of digital storage.

Until the advent of 'optical' media (see below), magnetic tape was the only form of high-density offline and archival storage medium for digital information. Modern magnetic tape is reliable and more robust than the early 'reel-to-reel' tape and the medium itself is cheap to manufacture and package. However, it is slow to access data stored on tapes, and their mechanical and physical complexity makes them vulnerable to some of the risks associated with long-term storage and handling.

5.2.2 Data recorded on optical media

Optical media are a popular but declining means of securely storing large volumes of data. Standards have been developed with the principal objective of ensuring that the optical medium itself is transferable between the many millions of devices in use. Whilst media costs are relatively low, contributing to its popularity, the current technology is such that a single magnetic tape can store more data than a single optical disk.

To popularise this media, most manufacturers use materials and manufacturing techniques that are suitable only for short term storage of data. The market for specialised media (for archival material, for example) is extremely limited. There is currently no International Standard for the production of high quality archive grade optical media.

5.2.3 Data recorded on solid state media

Solid state media are currently a very popular means of storing large volumes of data. This medium is relatively robust and extremely compact, although catastrophic failure is not unknown. Solid state media are not considered sufficiently mainstream for the long term storage of information, and are thus not recommended for this purpose.

5.2.4 Selection and use of digital media

Current research into media longevity and the issues arising from potential technical obsolescence suggests that storing records in digital-only formats carried unquantified risks. It is therefore not possible to recommend digital-only archiving at this time. The storage of hard-copy records is not without risk, as discussed above, but it is inherently simpler and there is far greater experience in the use and maintenance of these media.

Where digital records are to be stored, it is recommended that only premium quality media produced by major manufacturers should be used. It should be noted that certain types of magnetic media are intended for the 'consumer' back-up market and do not have archival life-expectancy: they are also less mechanically robust. Some disk media (for example Zip disks) are also intended for data transfer and short-term backup, and are not designed for archival use.

It is strongly recommended that digital data should be created in a widely used, non-proprietary file format. At present, there is no single format that meets all the best practice criteria but TIFF can be used to store high quality images, ASCII for unformatted text and PDF/A (BS ISO 19005) for text-based documents. It is possible to add proprietary features to these basic file formats but this should be avoided as it could restrict transportability in the future.

Both compression and encryption create problems for migration and possibly for future interpretation of undocumented bit-streams. Compression algorithms can destroy the patterns that would be useful to future IT experts in retrieving unknown data. It is therefore recommended that neither of these techniques are used.

A description of the files and technical details of the file format and other information (metadata) should be included with the files themselves. This information should be in hard copy form so that it can be read easily. The hard copy media should be the same as that recommended for the longest archival life. Information that would assist a future user to locate and understand digital records would include:

- unique identifiers for each record;
- description of content in a standard structured format;
- table of contents;
- indexes;
- provenance;
- location of equivalent hard copies;
- file format;
- operating systems used to create the data;
- information about the media;
- historical data (for example, creation data, migration dates, relocation dates).

5.3 Accessibility to recorded data

As with any media 'accessibility' to the recorded data is subject to three factors: readability, intelligibility and usability (see Section 2 for definitions).

Clearly, something that is unreadable cannot be intelligible, but the reverse is not true: a disk that has perfectly preserved data may be unintelligible if, for example, the data originally recorded on the disk represented a corrupt file or if the data cannot be matched with any existing application. However, there are some caveats. A small section of a disk might be unreadable, but intelligible information might be extracted from it by using the other associated data that was readable. Conversely, the alteration of a single bit might make some files or even whole disks unintelligible to their original application.

In order for the data to be useable, it has to be extracted from the storage medium and then interpreted by an application program. Therefore, the user needs some information about the recorded data - this is referred to as 'metadata'. The metadata should provide information about the creation and migration history of the data, the file structure and the hardware and software used to create it. In short it provides context to the recorded data, without which it is not possible to utilise the data. It is preferable if the metadata is retained in hard copy rather than digital form.

It should be noted that data usability may be compromised by any form of subsequent processing of the digital record - such as compression or encryption - so simplicity is a key factor in preserving usability.

The features of accessibility described above are not unique to digital media - they can apply equally to other media types. However, loss of readability to a paper record under 'normal' circumstances would be expected to be gradual and detected in sufficient time to enable some sort of migration exercise to be carried out. This could be described as 'graceful degradation'.

Unlike paper-based records deterioration of digital media and the associated loss of data stored on the medium is difficult to detect. Under certain circumstances, an unplanned or inadvertent change to a single bit of data may make an entire file unreadable or unintelligible. Deterioration resulting in the accumulation of several small errors can also render a whole disk or tape unreadable. This could be described as 'catastrophic degradation'.

Data are recorded on magnetic tapes in 'blocks'. Most tape systems include an error-correcting protocol that checks the data after they have been written and corrects any detected errors. Damaged areas of tape are also marked during this process so that they are not used in subsequent write operations. These error-correcting systems can operate in the background and be unknown to the user. This, potentially, could lead to the

concealment of the fact that the tape was below standard and consequently more vulnerable to deterioration.

6 Care and storage of records

6.1 Key considerations

There are a number of criteria relating to successful long-term storage that are common to all media types. These are:

- handling;
- temperature;
- relative humidity;
- exposure to light;
- gaseous contamination;
- particulate contamination;
- attack by vermin or fungal growths;
- security.

Other potential sources of risk may be particular to the media type, for example, exposure to magnetic fields or radiation. These factors and their associated risk are considered in the following sections.

The factors that are most commonly considered are temperature, humidity and handling. With respect to the first two, there is a general understanding that the long-term preservation of records will be adversely affected if temperature and humidity are not adequately controlled. Standards listed elsewhere in this guidance provide data on acceptable temperature and humidity ranges and the recommendations in these standards should be adopted. Of equal importance, however, is temperature and humidity stability. Sudden or significant changes can have serious long-term implications on the lifetime of the record, depending on the media.

6.2 Handling and care of hard-copy records

6.2.1 Paper records

Having created a paper record, the type and amount of handling it receives will have a significant effect on its life expectancy. The environment in which paper records are to be handled should be considered and potential sources of contamination controlled and, if possible, eliminated.

Certain materials that are often filed along with paper records should be removed before long-term storage is undertaken. The presence of certain foreign materials may accelerate degradation, create harmful atmospheres or attack the media or print. Foreign materials requiring removal include metal objects such as pins, staples, paper-clips and ‘treasury tags’ as their inevitable corrosion will damage and deface the paper. Plastic materials, especially PVC-type covers, should also be removed as chemicals contained in the plastic reduces the adhesion properties of carbon black toner.

Photocopying machines are a frequent source of damage to paper records. Where possible, a master set of records should be retained but not used for making multiple sets of copies. If it is necessary to use photocopying equipment, it should be kept clean and well maintained. Document feeders and automatic staplers should not be used as these are a common cause of damage to paper.

A storage regime should be established that minimises handling. Where it is necessary, strict procedures are to be employed and the use of protective gloves encouraged

(gloves should be carefully specified not only to protect records from harmful substances on the hands but also from chemicals in the gloves themselves). The environmental conditions in the archive store is one factor that is likely to significantly affect record longevity.

Finally, consideration should be given to the conditions experienced by the records prior to archiving or storage. It is very likely that no special measures will have been taken and poor environmental conditions may have resulted in chemical or particulate contamination, or infestation with vermin or fungal spores. These factors need to be taken into account before transferring to a storage facility.

6.2.2 Microform records

Microforms can be damaged by exposure to dust, dirt and fingerprints which will ultimately degrade the image quality and may also act as an absorbent and subsequently promote the growth of mould. As with other forms of photographic imagery, microforms are light sensitive. The effects of prolonged exposure to light should be considered when packaging, storing and accessing microfilms.

Procedures implemented for the handling of microforms should include the adoption of the following measures:

- use of lint-free gloves when handling silver halide film (oils and perspiration can damage the photographic emulsion);
- silver halide master films should not be used for routine reference purposes as the film rolling mechanisms on the reader and printer equipment can cause severe scratching of the gelatine emulsion;
- undertake regular surveys of the condition of the film in order to detect the signs of deterioration;
- reference films should not be left in viewing equipment as prolonged exposure to light will eventually affect the image quality.

6.3 Environmental conditions for storage

Experience, supported by specific research, has demonstrated that maintaining an appropriate storage environment can significantly enhance the long-term preservation of records, irrespective of the media used.

For optimum material stability and preservation, the lower the temperature and relative humidity of the storage area, the better, although a compromise may be required if staff are to have ready access to the storage facility.

The recommended conditions take account of three recognised storage regimes, namely:

- Combined storage and usage - where records are frequently handled or accessed but where controlled conditions are maintained.
- Access and retrieval only - where records are infrequently handled/accessed.
- Optimum preservation storage - where records are stored in ideal conditions with limited access and disturbance.

The environmental conditions should, above all, remain stable within the recommended range. Where materials are stored under ideal conditions, it is important to gradually acclimatise them before exposure to a different environment to prevent the formation of condensation.

Environmental conditions should be monitored and controlled, ideally, by an automated environment management system.

6.3.1 Storage of paper records

Poor storage conditions will have a detrimental effect on the condition of paper. Records, and copies of records, should be stored at specifically selected locations and an effective record management system should be implemented. Paper-based file covers, folders, wallets and envelopes used to store the records should conform to the same standards as the paper record itself. Before placing the paper records in any protective packaging, it is important to ensure that they are free of dust and unaffected by mould, insects or active corrosion and they do not contain any of the following materials:

- adhesive tape and 'Post-it' self-adhesive note paper;
- 'PVC'-type covers
- facsimiles printed on thermal paper;
- 'carbonless' paper;
- metal paper fasteners;
- elastic bands.

The condition of historical records should be carefully reviewed on a regular basis. The quality of the paper may be inferior to that used today. In addition, historical records may contain some of the 'proscribed' materials listed above. A thorough check of these records should therefore be undertaken before they are transferred to a storage facility. Where necessary, copies of original records should be made.

Most 'recognised' public records depositories have purpose built facilities where the environmental conditions can be carefully and accurately controlled. However, best practice experience suggests that of equal importance to maintaining the temperature and humidity is the maintenance of stable environmental conditions. Mould will start to grow at around 60% RH and if the humidity fluctuates by more than 10% in 24 hours, or the temperature is too high, the paper will become 'stressed' thereby accelerating its deterioration. It is recommended that paper records are maintained at a temperature between 12 and 18°C, and at a relative humidity between 30 and 60%.

6.3.2 Storage of microform records

The optimum method for storing microforms will depend on the precise nature of the material, the format and their intended use. The following guidance has been derived from that developed by the National Archives of Australia for the storage of microform.

Microfilm

- Microfilm should be wound onto standard size reels constructed from inert plastics or corrosion resistant metals. The loose end of the film should be secured using a piece of archival quality paper held in place with cotton tape. Rubber bands or sticky tape should never be used to secure a film.
- Each roll of film should be individually enclosed in close fitting sealed containers made from polypropylene, polycarbonate or archival quality cardboard. The size of the container should be commensurate with the size of the film.
- Labels must not be applied directly to the film and only the outside of the container should be marked. Adhesive labels may damage films even when applied to the container, so marking with permanent inks is preferable.

Microfiche

- Master microfiche should be individually enclosed in sleeves or envelopes made of inert plastics such as polyethylene, polypropylene or polyester, or archival quality paper. Plastic enclosures should not contain chlorine or plasticizers.

- Reference copies of fiche may not need individual enclosures as long as they are protected from excessive dust and light. Protection could be provided, for example, by plastic file boxes or drawers.
- Labels should not be applied directly to fiche or to individual enclosures and are usually not required as each fiche has its own header where control information can be recorded. However, if additional labelling is required, a permanent pen should be used to mark the non-image area of the fiche.

Aperture cards

- Aperture cards are normally only produced for reference purposes and can be stored as for reference fiche, in clean sturdy containers that exclude light and dust. The master copy would normally be retained as a roll film. However, if master aperture cards are required, they should be individually enclosed in the same way as a master microfiche.
- Storage furniture should be of coated metal construction. Wood should be avoided as it can, under certain circumstances, give off harmful vapours, can contribute to the spread of fire and may harbour insects. Specially designed storage cabinets for microform are readily available. It is recommended that microform records are maintained at a temperature between 12 and 18°C, and at a relative humidity between 30 and 40%.

6.3.3 Storage of magnetic media

As with paper-based media, temperature and humidity will affect the longevity of the medium. A high humidity level will present the main risk as this may promote hydrolysis in the binder material. The risk is increased where high humidity is coupled with higher temperatures (that is, above 'normal' room temperature, or, 20°C). Air conditioning and dehumidifying equipment will often be necessary to maintain the recommended storage conditions. Where high humidity cannot be controlled by this method, a desiccant material may be used but care should be exercised as there may be a tendency to reduce humidity to such an extent that static electricity becomes a problem.

Atmospheric impurities can adversely affect the magnetic particles on tape. In addition to corrosion caused by excess moisture, some volatile chemicals can reduce tape lifetime by attacking the binder and the polyester substrate. It follows, therefore, that the atmosphere in the storage area should be kept as clean as possible. Sources of impurities include cleaning agents, paints or traffic fumes.

Magnetic tape can be damaged by a variety of storage and handling practices. Possibly the most important preventative measures are that tape should be wound to the recommended tension and that the tape reels or cartridges should be constructed such that the tape is wound evenly without irregularities that could cause it to deform over time.

Finally, the presence of magnetic fields created by magnets or electronic equipment has the potential to alter the orientation of iron particles on the tape thereby deleting or indirectly altering the recorded data. Magnetic media should therefore be stored in cabinets that eliminate this particular risk.

The importance of stability of temperature and humidity has already been noted for paper-based records and this applies equally to magnetic media. An ANSI standard recommends that temperature and humidity fluctuations should not be greater than ±2°C and ±5%, respectively, in 24 hours [10]. It is recommended that magnetic media are maintained at a temperature between 16 and 20°C, and at a relative humidity between 30 and 40%.

6.3.4 Storage of optical media

Disks can be damaged by a variety of storage and handling practices. Recommendations for the storage of optical media can be found in the American Standard ANSI/PIMA IT9.25-1998 [11], which details a wide range of recommended practices. British and International Standards provide recommended practices to minimise damage (see Section 2). The particularly vulnerable part of an optical disk is the coating protecting the reflective and data carrying layers.

The effects of light and atmospheric pollution on the integrity of optical media are similar to those that have the potential to affect magnetic tape. A variation in humidity of no more than ±10% over a 24 hour period is quoted in the American Standard. Temperature stability does not feature in either standard although it would seem to be sensible to maintain it at similar levels to those required for magnetic tape.

The storage temperature for optical disks should not fall below -10°C and relative humidity below 5%. It is recommended that optical media are maintained at a temperature between 18 and 22°C, and at a relative humidity between 35 and 45%.

6.4 Security

The storage location itself should be suitably secured depending on the perceived risk (see Section 6), with perimeter barriers and access controls for staff and visitors. Storage locations should be well constructed and capable of maintaining the environmental conditions that will give the best life expectancy for the stored media.

Security procedures should be established such that not only damage to the media is prevented, but that unauthorised changes, amendments and deletions to the primary recorded data, irrespective of media, are prevented.

Detailed requirements for the physical and environmental security of records and details building requirements, protection and access restrictions are given in the International Standard ISO/IEC 17799 [12].

7 Long-term integrity of records

7.1 Identification of threat and creation of a risk register

In order to develop a robust information management system, it is necessary to identify the threats to the accessibility to the data. It is also necessary to identify and, if possible, mitigate threats to the integrity of both the media and the information it contains during the period of archiving. The following statements are to be found in international quality standards:

> ISO9001:2000 Quality Management System Requirements Section 4.2.4 'Control of Records' requires that "*Records shall remain legible, readily identifiable and retrievable. A documented procedure shall be established to define the controls needed for the identification, storage, protection, retrieval, retention time and disposition of the records".*
>
> ISO9004:2000 Quality Management Systems Guidelines for Performance Improvements Section 5.4.2 'Quality Planning' states that one of the inputs for effective and efficient planning includes *"…related risk assessment and mitigation data".*

In addition, guidance for Inspectors on the Conditions Attached to Nuclear Site Licences states (Condition 6)

> *"The arrangements … should include details of both the identity of the records to be preserved and a description of the means employed for preservation … Means of preservation should take account of legal requirements, ageing, fire, flood, the possible need for urgent retrieval and potential obsolescence of retrieval mechanisms."*

These requirements point to the need to identify, at an early stage, the risks associated with preserving information over the long-term. A typical risk register could address the following risk factors:

- physical catastrophe;
- accidental loss;
- theft;
- deliberate damage;
- technical obsolescence;
- data corruption;
- media decay;
- contamination;
- loss of metadata;
- inauthentic data;
- records not created or created incorrectly;
- management risk.

Early identification of threats will enable the information management system to mitigate against (or at least have the capacity to do so) any resulting risk. The actions required in response to an identified threat can be characterised in one of two ways.

First there are preventative actions. These are actions that minimise either the likelihood or the frequency (or both) such that the risk is reduced to an acceptable level. A typical example of a preventative action is the installation of a fire detection and suppression system in the records storage facility.

The second type is a business continuity or 'recovery' action. This is a pre-emptory action that puts the organisation responsible for the records in the best possible position to fully recover from the effects of a realised threat. An example of this type of action would be to copy all records and store them at a second location.

7.2 Waste package records and the NDA Archive

Vast numbers of civil nuclear records, plans, photographs, drawings and other important data and information, some dating back to the beginning of the UK nuclear industry, are currently stored in various locations around the country. The NDA is accountable for these records and their preservation, ensuring that they remain secure, their integrity remains intact in the long-term and that they are accessible in line with legislation and the relevant regulations.

The NDA Archive, which is located in Caithness, is currently being constructed and will become operational in January 2017. All waste package records within the NDA estate shall be archived at this facility. The NDA Archive will also offer services for transferring waste package records to different media formats, which meet the guidance for media and storage that have been identified in this document.

8 Summary and overall recommendations

This guidance is designed to identify the issues relevant to the management and storage of records created on various media over a period of at least 150 years.

There is a wide range of media currently available and which is potentially suitable for the recording of waste package information. Each medium has different characteristics, strengths and weaknesses and hence optimised management regimes may differ. The principal conclusion that can be drawn from the information contained within this guidance is that whatever media is selected, successful storage and continued accessibility to the data is largely dependent on the records management system implemented.

The system should be well supported by senior management and resourced appropriately. It should be recognised that records for current and past waste management activities will be required for many decades. In addition to maintaining the media itself, it is vital that the data remains accessible (readable, intelligible and usable). This factor is particularly pertinent where digital media are used.

The transfer of records to a long-term archive facility should not be considered as the 'final act', nor their management an after-thought. The need to accurately create, manage and preserve data should be an integral part of the company management process. Consequently, this part of the process should be thoroughly planned, managed and properly funded. The risk to future generations if inaccurate or inaccessible records are created is considered unacceptable.

The nuclear industry must be clear about what records should be retained for the long-term and should adopt a strategy for their migration onto chosen media. Records Managers should be appointed who are ultimately responsible for developing and implementing procedures that ensure key records are appropriately managed.

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Certificate No LRQ 4008580

Radioactive Waste Management Limited
Building 587
Curie Avenue
Harwell Oxford
Didcot
Oxfordshire OX11 0RH

t +44 (0)1925 802820
f +44 (0)1925 802932
w www.nda.gov.uk/rwm