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Methods for Maintaining a Record of Waste Packages during Waste Processing and Storage



IAEA

International Atomic Energy Agency

**METHODS FOR MAINTAINING
A RECORD OF WASTE PACKAGES
DURING WASTE PROCESSING
AND STORAGE**

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DURING WASTE PROCESSING
AND STORAGE**

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2005

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FOREWORD

During processing, radioactive waste is converted into waste packages, and then sent for storage and ultimately for disposal. A principal condition for acceptance of a waste package is its full compliance with waste acceptance criteria for disposal or storage. These criteria define the radiological, mechanical, physical, chemical and biological properties of radioactive waste that can, in principle, be changed during waste processing. To declare compliance of a waste package with waste acceptance criteria, a system for generating and maintaining records should be established to record and track all relevant information, from raw waste characteristics, through changes related to waste processing, to final checking and verification of waste package parameters. In parallel, records on processing technology and the operational parameters of technological facilities should adhere to established and approved quality assurance systems. A records system for waste management should be in place, defining the data to be collected and stored at each step of waste processing and using a reliable selection process carried over into the individual steps of the waste processing flow stream. The waste management records system must at the same time ensure selection and maintenance of all the main information, not only providing evidence of compliance of waste package parameters with waste acceptance criteria but also serving as an information source in the case of any future operations involving the stored or disposed waste.

Records generated during waste processing are a constituent part of the more complex system of waste management record keeping, covering the entire life cycle of radioactive waste from generation to disposal and even the post-closure period of a disposal facility. The IAEA is systematically working on the preparation of a set of publications to assist its Member States in the development and implementation of such a system. This report covers all the principal aspects of the establishment and maintenance of records during waste processing and storage.

The IAEA is grateful to the consultants and reviewers who took part in the preparation of this publication, particularly M. Robinson (Los Alamos National Laboratory, USA), who chaired both consultants meetings. The IAEA officers responsible for this publication were V. Tsyplenkov and R. Burcl of the Division of Nuclear Fuel Cycle and Waste Technology.

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1. INTRODUCTION

1.1. BACKGROUND

For the purposes of this report, a ‘record’ denotes any completed paper document, drawing, film or electronic medium recording the characteristics and locations of waste packages, and documenting that items or activities which are relevant to radioactive waste safety are in compliance with established requirements. An item is also considered a record if it provides evidence of regulatory compliance. Records are an essential part of safety standards and a quality management system [1–8].

Within an overall waste inventory records keeping system, a waste package represents a fundamental unit used as a reference basis for controlling information and making decisions with due consideration of interdependences among and between various steps in radioactive waste management. Records generated during radioactive waste treatment, packaging, conditioning, storage, decommissioning of nuclear facilities, transport and disposal, as described, for example, in Refs [4–7, 9–16], are important, not only for establishing conformance of the waste packages but also with regard to authorized discharges [17] and the appropriate response to releases or accidents. Such records also form the basis for fulfillment of the reporting requirements under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [18] and for post-closure disposal facility records which may be essential to future generations [13, 15].

Storage of radioactive waste has long been practised for various technical, economic or policy reasons. Storage is by definition an interim measure [8, 10]. Long term storage of waste is becoming an increasingly important and topical issue since a number of Member States have encountered difficulties in the development of complete disposal processes for various waste types. Therefore, some States plan to put such wastes in storage facilities for longer periods until disposal systems and facilities are designed and constructed. Such storage should not be defined as interim storage.

In some cases waste containers have experienced significant degradation while in storage. At some older disposal facilities there have been releases to the environment resulting in ground contamination. Reasons for these failures include inadequate characterization of the waste, unsatisfactory performance of isolation barriers, and inadequate control of the nature and inventory of long lived radionuclides and other chemical pollutants introduced in the waste packages or repositories [19].

Consequently, traceability of wastes in storage or disposal facilities, from original characterization through assay, conditioning, storage and disposal, has been found to be vital in facilitating remedial actions, including waste retrieval. In addition, for both planned and/or emergency situations leading to retrieval of waste from a storage or disposal facility, complementary records, including the results of site investigation, design, construction and operation of the facility, are essential.

As time goes on the value of such records will increase for any Member State dealing with radioactive waste. Consequently, retention of records on waste packages generated during various stages of radioactive waste management is considered to be a matter of particular importance and should be subject to a system of maintenance and control as described in this report.

1.2. OBJECTIVE

The objective of this publication is to provide guidance on best practices for maintaining records of waste packages during processing and storage by waste generators, operators of waste management facilities, transport organizations, and storage and disposal facilities. It is intended that record control systems developed using this guidance be integrated with an overall quality assurance programme for radioactive waste packages, as described in Ref. [7].

1.3. SCOPE

This report is intended to serve as a source of guidance on current practices and methods for maintaining records of waste packages produced through various phases of the waste management process from waste generation through conditioning, storage and transport, until receipt of the waste packages at a disposal facility. It does not address the keeping of records required for the decommissioning of nuclear facilities or the post-closure phase of disposal facilities, which are addressed in other IAEA publications [13, 15, 16]. This report provides guidance in a generic sense as to types of documents that may be considered records, but it is suggested that in all cases the regulatory authorities in individual Member States and a particular waste management facility should determine specific records requirements and maintenance specifications.

The guidance given in this report also distinguishes between records that are maintained for the purpose of providing documentary evidence that the

overall auditable waste management system is being effectively maintained (e.g. conditioning procedures, personnel training records) and records required to demonstrate the acceptability of individual waste packages (e.g. waste characterization data, assay records). The guidance is intended to be broad enough to accommodate both large commercial nuclear facilities and smaller ‘institutional waste generators’ (e.g. industrial, medical, R&D or academic facilities). It is the responsibility of the relevant organization to adapt this guidance to its specific scope of operations.

This report is not intended to provide a full list of parameters that should be recorded; the scope and detail of the records will depend on the hazard and/or the complexity of the proposed operation and should be subject to approval by the regulatory body (or other responsible authority in accordance with national legislation). Experience in Member States that have implemented waste inventory record keeping systems shows that the list of parameters and types of records vary considerably and are usually provided by local legislation (examples of national experience, including templates and data sheets used in some Member States, can be found in Refs [15, 16]). The aims of this report are to provide general guidance and advice on the approach to and methods for records generation and maintenance, and to point out basic needs.

The key issues discussed in this publication are listed in Section 1.4. If a topic is not discussed but is nevertheless considered to be important, this is indicated and references to appropriate sources are provided. Physical security and protection of records is recognized to be an important issue that is outside the scope of this report. Guidance or recommendations on record keeping requirements for safeguards are also outside the scope of the present publication.

1.4. STRUCTURE

Section 2 provides justification for establishing a record keeping system and the requirements for waste management records. Section 3 defines issues important for the assignment of responsibilities for record generation, transmittal and retention, and Section 4 describes waste management records systems, including their classification. Section 5 briefly summarizes the report. More detailed guidance for practical implementation of waste management records systems, including generation of data and maintenance of records for individual packages, is given in the five appendices.

2. REQUIREMENTS FOR WASTE MANAGEMENT RECORDS

The requirements for waste package records management originate from regulatory requirements established by each Member State [2], the intended repository waste acceptance criteria, the authorization basis (safety case) for the transport container and facilities at which the waste may be generated, conditioned and stored. Generally, these requirements are synthesized and imposed on the various organizations involved in the entire waste management process through licence (authorization) conditions, as described in Refs [3–7, 9–16].

Basically, an appropriate integrated facility management information system shall be established and implemented. The typical elements of such a system include:

- (a) Waste management records;
- (b) Design records;
- (c) Financial records;
- (d) Human resource records;
- (e) Licensing and statutory records;
- (f) Quality assurance records;
- (g) Operation and maintenance records;
- (h) Health and safety records.

The facility's information (records) management system should ensure that records are [6]:

- (1) Categorized;
- (2) Registered upon receipt;
- (3) Readily retrievable;
- (4) Indexed and placed in their proper location in the facility's files with the retention period clearly identified;
- (5) Stored in a suitable form in a controlled environment and protected from fire, flood, theft, etc.;
- (6) Corrected (updated) or supplemented to reflect the actual status of the facility.

In addition, records are required to be clear, legible, complete, categorized as permanent or non-permanent, and readily available for

inspection. The system should be able to identify and track any individual object, service or process involved. The system must be designed to resist tampering or alteration and should provide appropriate backup or redundancy to ensure that data will not be lost as a result of accidents or unexpected events. Multiple copies of the records or access to the database by several authorities may be required. Only authorized individuals should be allowed access to the records system or database. Modification of the documents must be subject to the same level of review and approval as applied to the originals. At any disposal site, records should be maintained for the required period of time and should therefore be made of appropriate material to resist deterioration for the required retention period.

Some records, designated as classified (for example for materials or facilities transferred from military to civilian use), confidential or property records can have a special status that limits their availability and/or distribution. This may require special provisions for their management without adversely affecting quality control. Information on such records must be incorporated into the records management system together with an appropriate description (explanation).

In general, two types of records are necessary to support the waste management process:

- (1) Those that are specifically required to describe individual waste packages;
- (2) Those that demonstrate that organizations are operating within the parameters of their licence or authorization procedure.

Records that provide documentary evidence of waste package acceptability for disposal, such as characterization data, assay records and certifications of compliance with waste acceptance criteria, do not necessarily travel with individual packages through each step in the waste processing (conditioning), storage, transport and disposal process, but must be readily retrievable by means of the individual package identification number at any stage in the process. A records file, the technical content of which is determined by the disposal facility waste acceptance criteria, must ultimately be transmitted to the disposal facility operator at the time of submission of an individual waste package for disposal. The actual logistics of generation, collection and interim retention of such record files should be determined through arrangements between all parties involved in the waste management process. This general logic is illustrated in Fig. 1.

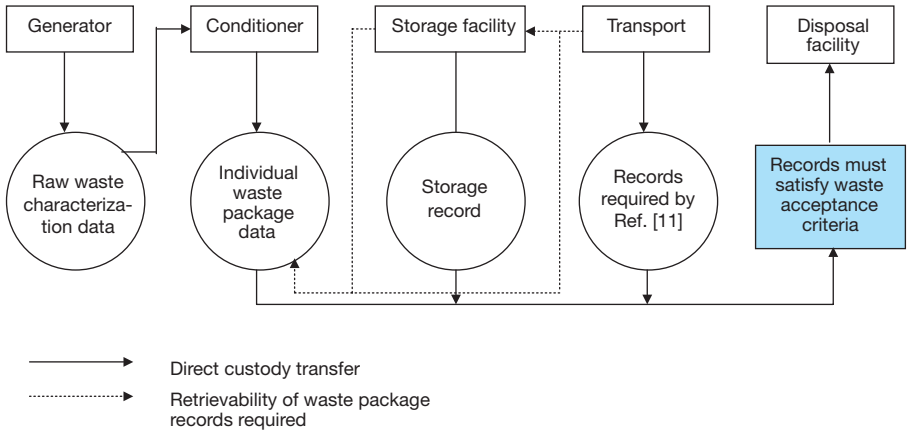


FIG. 1. Responsibility for waste package records and transfer of custody.

Records that provide documentary evidence that each organization is operating within its authorization basis are varied in nature and will vary from facility to facility. Generally, such records do not accompany waste packages but must be available at each facility for inspection or audit. Examples of such records are given in Fig. 2.

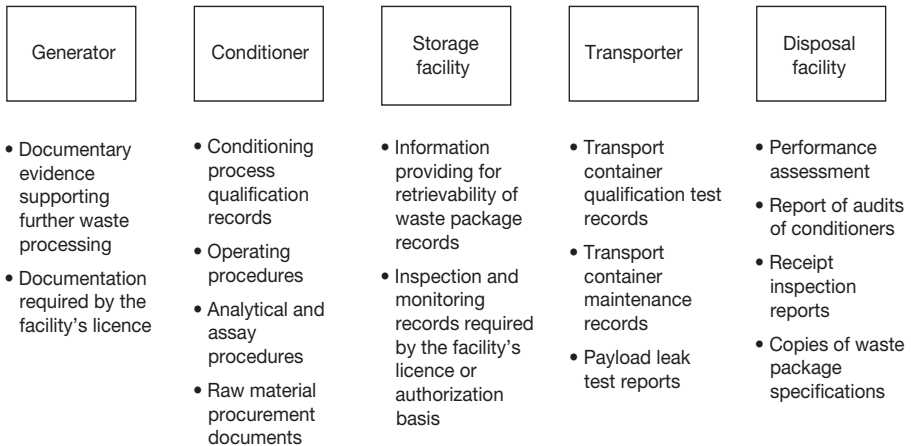


FIG. 2. Typical operational records supporting waste package acceptability.

Since computer based systems have become basic to the management of data and information, it is considered good practice that the record keeping systems for radioactive waste facilities also be computerized. Due to the ability to deal speedily with massive amounts of available and continuously collected information, a computer based integrated facility management information system can enable efficient access to all categories of records and enhance work effectiveness and reliability.

The use of computerized equipment and systems in radioactive waste management is rapidly increasing. Such technology will increase and help facility operators to avoid unnecessary duplication of effort and facilitate the sharing of information. As technology increases our command of information, the amount of data that must be collected, processed and analysed will expand proportionately. In this situation, it is important to ensure that the software used for collection and processing of technological information in radioactive waste management contributes to, rather than compromises, its safety.

Long time maintenance of computer records for long term storage or disposal of waste packages causes technical problems arising from the rapid development and changes in computer technology, communication and control systems. If records exist only in digital media there is a real risk of incompatibility of new software and hardware systems with long term stored data. Therefore computer records have to be regularly updated and adapted to new conditions. Another option is to transfer the computer files to another medium to ensure future consistency and compatibility of all parts of a waste records system.

Copying of records from one medium to another may result in those records not being legally admissible. The records system should therefore ensure that records are kept in the appropriate medium, and that copying to accommodate new technology and maintain image quality during the storage period is adequately controlled. These and other technical as well as regulatory issues of long term record keeping are further discussed in Appendix I of this publication and in Refs [6, 13]. The general principles and techniques for the utilization of safety critical software at nuclear facilities, as well as advantages and shortcomings of computer based systems used in the nuclear industry, are discussed in detail in Ref. [12].

3. RESPONSIBILITIES FOR RECORDS GENERATION, TRANSMITTAL AND RETENTION

As various organizations and time-frames may be associated with the management of waste from generation through disposal, it is imperative that responsibilities for records generation, transmittal and retention be established and implemented.

Each organization involved in the waste management process should establish responsibilities and requirements for records generation, approval, transmittal, potential correction and/or supersedence, maintenance and retention (as described in detail in Section 4) in their quality management system. A good practice for ensuring implementation of such a procedure is to incorporate specific requirements for records generation and transmittal in operating procedures for individual technological equipment. For example, an operating procedure for a cementation process should stipulate what documentation should be prepared, what level of approval is required, and responsibility for retention and transfer of such records. Additionally, waste management organizations should maintain the procedures defining the responsibilities for generation and collection of records specific to individual waste packages and the further disposition of such records (see Section 4).

In all cases, it is important to devise and document a mechanism for traceability of records by individual waste package using identification numbers or codes. The technologies that facilitate this traceability are described briefly in Appendix I. Where multiple organizations are involved in the waste management process, it has also proved very helpful to coordinate methods of identification and traceability so that records from one organization are readily incorporated into processing records generated by successor organizations.

The organization which has overall responsibility for the final certification of waste as being acceptable for disposal should specify retention periods for all records and ensure, through specifications or other contractual means, that corresponding requirements are established for all organizations involved. Furthermore, such organizations should periodically verify whether records management is implemented satisfactorily in all involved organizations through audit or surveillance, or other means.

An important prerequisite for such verification is that the responsible organization has established rules for the retention (maintenance, preservation and protection) of records, and associated test materials and specimens, from the moment of receipt until their disposition. Such a records storage and

verification system, whether it is in hard copy or digitalized form, should include the following [6]:

- (a) A description of the document;
- (b) A description of the filing system to be used;
- (c) A method for verifying that the records received are in agreement with the transmittal document and that the records are in good condition;
- (d) A method for verifying that the records agree with the records index;
- (e) Rules governing access to and control of the files;
- (f) A method for filing corrected or supplemental information and voiding or disposing of records that have been superseded;
- (g) A method for maintaining control and accountability for records removed from the document storage facility;
- (h) Periodic checking to ensure that the records are not damaged, deteriorating or missing.

Upon transfer of the records, the responsible organization or its designee should acknowledge their receipt and process them. Access to records accumulated at locations not under the control of a responsible organization should be agreed. Additional instructions for controlling activities of multiple organizations through specification and for audit/surveillance as a means of quality verification are provided in Refs [6, 7].

4. WASTE MANAGEMENT RECORDS SYSTEM

4.1. GENERAL

Each waste management organization should have a documented records system. Facilities charged with storing waste for extended periods of time (i.e. where development of a disposal facility is deferred), and disposal facilities in particular, should strive to develop a longstanding, sophisticated records system as information pertinent to waste inventories may even need to be retrieved in the far future in the post-closure phase of the facility. Elements of a records system established in accordance with the requirements defined in Sections 2 and 3, applicable to waste management, are further described in this section.

4.2. IDENTIFICATION OF RECORDS TO BE INCLUDED IN THE RECORDS SYSTEM

Documents and data that should be included in a records system are those that are necessary to demonstrate that a waste package satisfies disposal facility waste acceptance criteria and those that provide evidence that an organization or facility is operating within its authorization basis. Examples of such documents are provided in Section 4.3.5. It should be recognized that many documents have intrinsic value as records as they support conclusions that can be drawn on waste characteristics. For example, a waste generator's operating procedures and material procurement records may be essential to establish process knowledge regarding as-generated waste forms. In some cases, records of (pre)treatment processes may contain information that cannot easily be verified subsequently (e.g. radiochemical analyses of the isotopic composition of feed streams to vitrified high level waste). A conditioning facility's operating records may be necessary to establish confidence in the properties of the conditioned waste form. Consequently, the retention and traceability of such records is of great importance.

As a general rule, all documentation that contributes to the knowledge base regarding waste characteristics and all documentation relevant to operational procedures should be considered for inclusion in the records system. Appendices II and III provide, respectively, a summary and detailed guidance as to the minimum technical content required for records of waste packages. Appendix IV provides the general logic as to which organization is responsible for generation and retention of records supporting the acceptability of waste packages. Specific guidance for institutional waste generators is provided in Appendix V.

4.3. RECORDS SYSTEM

A records system is Member State specific. However, the type and quality of data should be examined in the context of international perspectives such as waste classification systems, the IAEA waste management databases, the possibility of establishing regional repositories and the possibility of a future international archive for repository information [15]. A system should be established by each organization handling and processing waste and be integrated with the overall waste management record keeping system. The system should be defined, implemented and enforced in accordance with written procedures and instructions and validated computer software (if applicable). The system should provide for generation, approval, transmittal,

possible correction and/or supersedence, maintenance, retention and disposition of all records important to safety. These records should include, as appropriate [4, 5]:

- (a) Data needed for a national waste inventory;
- (b) Data needed for waste characterization;
- (c) Records from the control process for treatment, packaging and conditioning;
- (d) Documentation on the procurement of containers required to provide confinement for a specified period (e.g. in a repository);
- (e) Specifications for waste packages and audit records of individual containers and packages;
- (f) Operating performance trends;
- (g) Incidents of non-compliance with the specifications for waste packages and the actions taken to rectify them;
- (h) Monitoring records;
- (i) Records of safety assessments;
- (j) Written operating procedures;
- (k) Any additional data required by the regulatory body.

4.3.1. Generation of waste records

The records to be generated and the method of their transmittal to the records retention system should be specified by administrative and/or operational procedures, design specifications, procurement or other documents. The generated documents should be legible and amenable to reproduction. Documents should be complete and approved by authorized personnel. Such records should be considered valid only if dated, stamped, initiated, signed or otherwise authenticated. An identification (index) should be assigned to the documents, making them traceable to the waste process and/or product.

4.3.2. Receipt, indexing, transmittal and distribution of records

Procedures should be established to provide for the documented receipt and transmittal of records at each step of the waste's life cycle. Records should be indexed upon receipt, according to a documented system providing for ease of retrieval and maintenance of traceability of records to their associated waste process and/or product. Where incremental waste processes are performed by different organizations, every effort should be made to coordinate records

identification systems between all involved organizations to facilitate record use and retrieval.

Distribution of records should be controlled to ensure transmittal to authorized organizations and designated retention locations. Software for electronic transmission of records should be verified and validated (data transmission technology is discussed further in Appendix I).

The scope and content of a transmitted record should be determined and approved for each phase in the lifetime of the waste. In addition to basic waste characterization, such data serve as the basis for further technological decisions and therefore are usually transmitted to follow-up organizations. For example, a waste generator provides a summary of process knowledge for individual items of as-generated waste to the conditioning facility so the conditioning facility can determine an appropriate treatment and conditioning procedure. The conditioning facility retains the process knowledge documentation for the purpose of future historical investigations and/or audits and generates characterization data (records) for the conditioned waste form to allow the disposal facility to verify satisfactory compliance of a waste package with waste acceptance criteria. Other organizations have no need of the characterization records themselves, but require either access to or a summary of characterization information. Conditioning records must be retrievable at a storage facility by container identification number, for example if investigation is required because a release has occurred or container integrity is found to be deteriorating. On the other hand, if no disposal facility is foreseen within a reasonable time-frame and waste is intended to be stored at a national or regional storage facility for an extended period, it may be appropriate to transmit the entire file of records for individual waste packages to the storage facility operator for retention. Transport organizations usually require only a summary of package characteristics to determine compliance with transport container limits [11]. Appendix IV provides a simplified matrix for generation, distribution and retention of waste records.

4.3.3. Correction, supersedence and voiding of records

Procedures should be established to control the correction, supersedence and voiding of records. The procedures should ensure that only authorized personnel perform these activities and that the revised, corrected, superseded or voided records clearly reflect the reason for the change. These procedures should also ensure that all affected documentation is revised when such changes are made and that revised records are redistributed if necessary. Correction fluid, tape or any correction method that obscures original data should not be used.

4.3.4. Maintenance and environmental protection of records

Procedures should be established to ensure the regular maintenance of all kinds of records, including hard copy, digital records and filmed reproductions. Record retention facilities should provide for environmental protection of the latter type of record, including measures to protect against all kinds of degradation, e.g. through humidity, temperature, mould, insect or rodent infestation, or fire. Basic architectural specifications for a record retention facility may be found in Ref. [20]. Magnetic media should also be protected from excessive light and electromagnetic fields. Backups should be produced of digital records (floppy disk, CD-ROM, hard drive or tapes).

Where facilities meeting all of these requirements are not available, dual storage of records in facilities sufficiently remote from one another to preclude their being simultaneously exposed to the same hazard is an option. Such dual storage facilities should not permit environmental damage to records.

Temporary storage of records for the purposes of processing, review or frequent use should be arranged in metal cabinets providing not only physical but also reasonable fire protection. Procedures should specify the maximum allowable duration of temporary storage and administrative procedures for access to and control of records.

4.3.5. Classification of records

Records should be classified as permanent or non-permanent by each organization involved in radioactive waste management. Generally, procedures need not be permanent if the recorded results can be interpreted without recourse to them. However, when interpretation of the results depends on knowledge of the procedures, both should be classified as permanent [6]. In particular, waste management records should be classified according to the following guidance.

4.3.5.1. Permanent records

Permanent records are those that would be of significant value in:

- (a) Demonstrating that the waste form, container, waste package or transport container is in safety or regulatory compliance;
- (b) Responding to an accident or radioactive release;
- (c) Repairing or reworking of a confinement barrier, accident detection or mitigation system;
- (d) Noting doses from either historical or future releases.

Following are examples of permanent records related to waste packages:

- (1) Waste characterization data;
- (2) Documentation supporting process knowledge;
- (3) Qualification records for waste treatment and conditioning processes;
- (4) Treatment and conditioning process control records;
- (5) Waste container and transport container design documents and performance based test qualification records;
- (6) Non-destructive examination procedure qualification records for waste containers (non-destructive assay, container radiography, visual examination, etc.);
- (7) Material certification and production records for containers required to act as confinement barriers for extended periods in the repository;
- (8) Assay records for individual waste packages and transport container payloads (original manufacturer's certification and decay calculations for sources);
- (9) All other data required for safety or performance assessments of critical parameters of the waste form, container, waste package and transport container on an individual waste package and transport container payload basis;
- (10) Waste package specifications.

Permanent records required by the waste repository usually include:

- (i) Waste characterization data;
- (ii) Assay records for individual waste packages;
- (iii) All other data required for safety or performance assessments of critical parameters of the waste form, waste container and waste package on an individual waste package basis;
- (iv) Waste package specifications.

Where no repository exists as yet, waste processors should assume that permanent records required by the repository, as a minimum, are those needed as baseline data for the operational and post-closure safety assessment of the repository.

4.3.5.2. *Non-permanent records*

Non-permanent records are those required to demonstrate that an activity was performed in accordance with applicable requirements, but which

need not be retained beyond the lifetime of the facility or after a waste package has been transferred from one organization or facility to another.

Examples of non-permanent records include:

- (a) Personnel qualification records;
- (b) In-process inspection records;
- (c) Periodic storage inspection records;
- (d) Chain of custody records;
- (e) Laboratory standard certifications;
- (f) Container procurement documents (for containers not assumed to provide confinement for extended durations in the repository);
- (g) Calibration records;
- (h) Audit records;
- (i) Transport container post-loading test reports and inspection reports.

5. SUMMARY

The generation and maintenance of proper records during radioactive waste processing, resulting in a comprehensive set of waste package characterization data, is essential to demonstrate compliance with waste acceptance criteria for disposal and/or storage.

Historical experience at radioactive waste disposal facilities that have experienced environmental releases and at other nuclear facilities where insufficient information on stored conditioned wastes has resulted in the need to perform extensive intrusive sampling and analysis, provides a convincing argument for and demonstration of the importance of an effective records management system. Where long lived isotopes are to be dealt with by geological disposal, waste management records may be important for many future generations.

This report deals with part of an overall (integrated) records management system, in particular for records related to the predisposal phase of radioactive waste management. It provides general guidance on generating and maintaining a record of waste packages during their production (waste processing), transport and storage before final disposal.

This report covers all principal aspects of establishing and maintaining records, including their generation, approval, transmittal, potential correction and/or supersedence, retention and disposition. Waste management record

requirements, the main components of a waste management records system and basic responsibilities are also identified in the report.

The major observations of this report are as follows:

- (a) Within an overall waste inventory record keeping system, a waste package represents a fundamental unit used as a reference basis for controlling information and making decisions with due consideration of the impacts and/or needs at various steps in radioactive waste management linked with safe disposal.
- (b) A basic requirement is that an appropriate records management system be established and approved by the regulatory body for generating and maintaining records of waste packages during processing and storage, and implemented by waste generators, operators of waste management facilities, transport organizations, and storage and disposal facilities.
- (c) Generally, two types of records are needed, those that are specifically required to define individual waste packages and those that demonstrate that waste management organizations are operating within their licence or authorization basis. The list of specific parameters and types of records may vary in different countries and is usually defined by local legislation.
- (d) The records system should ensure that records are kept in an appropriate medium to provide durability and readability, and are retrievable. Transfer of information to accommodate new technology and the image quality during the storage period should be adequately controlled.
- (e) It is considered good practice that the record keeping systems for radioactive waste management be computerized. It is important, however, to ensure long term maintenance of computer records in a manner consistent with regulatory and other applicable requirements, and to reflect the rapid development of computer technology.
- (f) The responsible organization should specify retention periods for all records.
- (g) The responsible organization should also ensure (through periodic verification and auditing) that waste management records requirements are observed and implemented satisfactorily in all involved organizations.

The guidance provided in this report should be implemented to the extent appropriate for the scope of an organization's activities as an essential element of the current and future safety envelope for waste management activities. Furthermore, as records provide documentary evidence of compliance with regulatory requirements, it is in every waste management organization's best interest to ensure their preservation.

Appendix I

AVAILABLE TECHNOLOGIES FOR STORAGE OF RECORDS, DATA TRANSFER AND WASTE PACKAGE IDENTIFICATION

Records for individual waste packages and records demonstrating compliance of operational procedures with an organization's authorization basis must be maintained in a form which:

- (a) Facilitates ease of retrieval;
- (b) Is compatible with the need for onward transmission to the next stage of the process, e.g. the final repository;
- (c) Can be maintained for the time period required by the category of record, as discussed in Section 4.3.5.

Various technologies have been developed and are suitable for radioactive waste management record keeping purposes, as described below.

I.1. TECHNOLOGIES FOR RECORD STORAGE

I.1.1. General

The medium chosen for a particular application will be determined by the anticipated subsequent use of the data and by requirements (a)–(c) specified above, with due consideration of any special needs for processing and control. For instance, if it is expected that the data records will be transferred at some stage in the future and be subject to further manipulation and analysis, then a flexible format such as magnetic or optical disk may be preferred.

It should be noted that the durability of many data recording media may not be threatened by physical degradation but from the inability to access the record due to advancements or changes in technology. It is recommended that measures be taken to archive data reading systems as well as the records themselves to guard against this eventuality. Of course, another solution may be to transfer the records to a new retention medium. Such a transfer would require a documented technical and/or legal validation that the record transfer is complete and accurate prior to re-archiving of the material.

I.1.2. Hard copy (paper)

Paper hard copy is the traditional medium for maintaining records. For applications requiring retention in excess of a few decades, permanent papers should be utilized.

Regular paper, which may be the most common medium for existing records, can often not be expected to have a lifetime longer than a few decades, mainly because of the acidity of the pulp. The advantages of this medium are that it is already in a form suitable for storage, it is readable without tools, and copies easily. The disadvantages are that it may not meet the requirements for long term readability and it is a relatively bulky medium, requiring large and costly storage facilities.

Permanent paper, which has an alkali reserve, has a lifetime of several hundred years if conserved under specified conditions (no light, low relative humidity, minimal handling, acid-free physical contact). It is directly readable and easy to copy, but it is necessary to study the characteristics of the combination of paper and printing material. The disadvantages are mainly linked to the constraints of the conservation conditions and its bulk, as mentioned above for regular paper.

I.1.3. Magnetic media

Magnetic media such as disk packs, storage modules, disk cartridges and magnetic tape on an open spool are considered to be acceptable for records with retention periods of up to 30 years. The advantages of magnetic media are a large storage capacity, widespread use, and rapid retrieval and copying capabilities. A potential disadvantage as compared to microfilm or paper is that in some Member States the integrity of the data is considered insecure. Magnetic disks may not be admissible as legal documents, since undocumented changes can be made easily or data can be destroyed by magnetic fields. Another disadvantage is the need to maintain controlled environmental conditions. Flexible disks (floppy disks) and magnetic tape cartridges have lower life expectancies and should not be relied upon for more than three years.

I.1.4. Microfilm

Microfilm, microfiche and other microforms are suitable media for recording information, particularly in cases where the information record is not expected to require further revision by subsequent users of the data. Given appropriate storage and environmental conditions, these media are considered

to be acceptable for records with retention periods of up to 30 years, although lifetimes of 100–200 years are quoted for silver gelatin archival film. The advantages of microfilm are its relatively small storage space requirements and that it can be read directly with simple magnifying tools. The disadvantages are that special tools are required for copying to other media, the maximum number of replications of the microfilm itself is considered to be four, and there are requirements for minimal handling. Another disadvantage is that transferring information from microfilm to other media has been shown to decrease the quality and readability of the output information.

I.1.5. Optical laser disk, compact disk, digital video disk

The optical laser disk format is finding increasing use for radioactive waste record keeping. The optical disk itself can have a durable lifetime in excess of 100 years but there is uncertainty with respect to the readable lifetime achievable. In view of this, it is accepted that this medium is acceptable for records with retention periods of up to five years. After this time, periodic checks should be made for any deterioration in image quality. The records should be copied onto a new optical disk if any deterioration of image quality is found or if the document imaging system is to be replaced by a new, incompatible system. Periodic evaluations of technological developments and quality assurance are therefore required for this medium.

Optical disks have the same advantages and disadvantages as magnetic disks, although in practice it is more difficult to make undocumented data changes. The biggest disadvantage of optical disks is the current uncertainty as to their readable lifetimes.

I.2. TECHNOLOGIES FOR DATA TRANSFER

Hard copy data transfer

This is the traditional method of transferring records between one organization and another. Procedures as described in Section 4.3.2 should be established to ensure that data transfer is undertaken under an appropriate quality management system.

Magnetic/electronic data transfer

Transfer of data using magnetic media, optical disks or via an electronic link between computer systems is now common practice in many Member

States. To guard against undetected data corruption, additional controls should be included as part of the quality management system governing the receipt of waste package data.

The following measures are recommended as good practices:

- (a) Computer software developed to facilitate the transfer of data should be verified, validated and documented consistent with its nature, complexity and intended application, and in accordance with written procedures;
- (b) Where records are transferred via a modem link, checks should be carried out to confirm that the software used by both parties is compatible;
- (c) On receipt of data records, files should be opened and checked to ensure that the records are complete and legible;
- (d) Where electronic files are transferred to an optical disk, this should be done in accordance with an appropriate standard;
- (e) After transfer to a master disk, each file should be opened and the contents checked to ensure that copying has been completed successfully.

I.3. TECHNOLOGIES FOR PACKAGE IDENTIFICATION

Each package of radioactive waste prepared for interim storage and eventual disposal must be marked with a legible and permanent identification label. This is the primary means by which the record is linked to the waste package.

Media used for package identification include paper labels, metal tags, foil and direct marking onto the waste container itself. Measures should be implemented to ensure that labelling methods are qualified for their intended storage life and storage environment.

Bar codes and optical character recognition (OCR) systems [21] have been developed for radioactive waste management applications and have the benefit of permitting identifiers to be 'read' electronically and of allowing records to be updated in real time. Bar codes and OCR characters can be applied directly onto the surface of metallic containers by use of 'laser etching', which provides a permanent marking on the containers and which will have a lifetime in excess of a simple paper label.

The use of check digits for waste package identification is also recommended. A check digit (or digits) generated from the package identifier itself is added to the identifier in a check field. When the number is read or otherwise recorded, a checking algorithm can be utilized to confirm that the number has been read accurately.

Appendix II

MINIMUM CONTENT OF RECORDS DURING WASTE PROCESSING AND STORAGE (PROCESS ORIENTED)

Organization	Required record content
Generator	Documentary process knowledge Traceability to assay reports Analytical characterization (chemical and radionuclide composition) of raw waste Pretreatment and treatment processing (if any) Traceability of package sent for conditioning to raw waste source
Conditioner	Traceability from generator documentation to final package (or batch) identification Processing records including data on critical processing parameters ^a Assay records Chemical and radionuclide characterization of conditioned waste Records of inspections required by the waste acceptance criteria ^b Other specific attributes required by the waste acceptance criteria ^b (container configuration, shielding, gas generation rate, etc.) Independent inspection records (where required) Non-conformance records
Storage facility	Traceability of container identification to waste package records Location of individual packages Records of periodic inspection/monitoring Records of storage conditions
Transporter	Radionuclide inventory, external radiation field, surface contamination, presence of shielding, fissile mass Venting of container and flammable gas generation rate, if applicable ^c Records of incidents or accidents during transport
Disposal facility	All data required by the waste acceptance criteria ^b Emplacement location Non-conformance records including records of final resolution

^a Critical processing parameters and parameters to be inspected/monitored during storage are described in Refs [22–24].

^b Detailed information on waste acceptance criteria, including their derivation from the disposal facility performance assessment, is given in Refs [24–30].

^c Reference [11] provides detailed information on data required for transport of radioactive waste.

Appendix III

MINIMUM CONTENT OF RECORDS DURING WASTE PROCESSING, TRANSPORT AND STORAGE (WASTE PACKAGE ORIENTED)

III.1. RADIOACTIVE WASTE DATA

- (a) Origin (facility and location);
- (b) Current storage location;
- (c) Detailed description of the generation process (process knowledge);
- (d) Radiological characteristics (radionuclide inventory, activity, fissile mass, method and date of measurement, measurement error);
- (e) Chemical characterization, including content of chemically or biologically hazardous substances [23];
- (f) Physical characteristics (raw waste form properties, container configuration, weight).

Specific guidance for institutional radioactive waste generators is provided in Appendix V.

Radioactive waste data must in all cases be complete and valid, and must satisfy the conditioner's waste specification.

III.2. WASTE PROCESSING DATA

- (a) Waste package data:
 - Waste package identification;
 - Pretreatment and treatment process (processes to eliminate hazardous characteristics or constituents such as oxidation, pH adjustment, thermal decomposition) records;
 - Conditioning process (immobilization, volume reduction, etc.) records;
 - Parameters and conformance records for waste matrix materials;
 - Records of inspection/verification of critical process parameters [22];
 - Records of independent inspections required by waste acceptance criteria (if applicable);
 - Container information, including quality control records (manufacturer's specification, records of any required tests, material test reports if required);

- Waste package radiological characteristics (nuclide inventory, activity, fissile mass, decay heat, method and date of measurement, measurement error);
 - External radiological characteristics (surface dose rate, dose rate at 1 m distance, fixed and removable contamination, and presence/configuration of shielding);
 - Non-conformance records.
- (b) Operational records:
- Records required by the facility’s authorization basis;
 - Documentary evidence of implementation of the conditioner’s quality assurance programme [6, 7, 31, 32]

Conditioning records must satisfy the disposal facility’s waste acceptance criteria (see Refs [24–30]). Where a disposal site has not been identified and long term storage is foreseen, conditioning records must satisfy the waste acceptance criteria for storage as described in Refs [10, 24].

III.3. TRANSPORT DATA

- (a) Specific data required by Ref. [11];
- (b) Data required by the transport vessel safety case. The safety case may have more restrictive limits than Ref. [11], such as the following:
- Limits on hydrogen gas evolution;
 - Decay heat limits for individual packages;
 - Documented venting of individual packages;
 - Weight limits for individual packages and payload weight distribution limits;
 - Specific requirements for dunnage and package tie-down;
 - Leak testing of loaded vessels.
- (c) Reports of any non-conformance or incident during transport.

III.4. STORAGE DATA

- (a) Identification of stored waste packages and mechanisms for retrieval of waste package records;
- (b) Location;
- (c) Basic radiological parameters (summary of the radionuclide inventory, including external dose rate);

- (d) Records of inspections and/or monitoring of inventory [22] (for parameters to be monitored during storage);
- (e) Records of non-conformances.

III.5. DISPOSAL DATA

- (a) Waste package specification
- (b) The conditioner's records file for individual packages (this may be the entire records file or summary data, depending on the requirements in the individual Member State);
- (c) Records of non-conformances identified in conditioning, transport or storage, and evidence of their resolution and acceptance by the disposal facility;
- (d) Disposal facility receipt inspection and emplacement records.

Specific requirements for waste package records should be specified in the disposal facility's waste acceptance criteria [24–30].

Appendix IV

GENERAL RESPONSIBILITIES FOR GENERATION OF TECHNICAL DATA AND RETENTION OF RECORDS FOR WASTE PACKAGES

Type of data	Generator	Conditioner	Storage facility	Transporter	Disposal facility
Physical and chemical composition of raw waste	b	a			d
Nuclide inventory of raw waste	b	c			d
Activity measurement of raw waste	b	c			d
Container characteristics		b	d	d	e
Process and matrix characteristics		b	d	d	e
Waste package characteristics, waste form, weight, nuclide inventory, dose rate, surface contamination		b	d	d	e
Waste package storage location			b		
Waste package storage history			b		e
Demonstration of compliance with transport regulations				b	
Location of waste package in a repository					e
Independent inspection records (if required)					b, e
Non-conformance records and any additional operations		b	b	b	b, e

a: The conditioner will normally be required to retain generator assay and characterization data, and perform his own assay and characterization of the conditioned waste package.

b: Responsible for generating data.

c: Records retained during processing.

d: Package must be traceable to records.

e: Records retained for the post-closure phase.

Appendix V

SPECIFIC GUIDANCE FOR INSTITUTIONAL RADIOACTIVE WASTE GENERATORS

Institutional generators of radioactive waste are considered small generators [33–35] and generally include such organizations as:

- (a) Hospitals, pharmaceutical laboratories and academic facilities such as university laboratories and research reactors;
- (b) Industrial radiography and well logging facilities, and users of radioactive instrumentation such as flow measurement devices incorporating americium–beryllium neutron sources.

In almost all Member States, generators of nuclear wastes are considered legally responsible for their safe disposal. As accurate radioassay information and chemical characterization data are prerequisites to the conditioning of radioactive materials for disposal, institutional generators are cautioned as to the importance of maintaining detailed records related to the procurement and use of nuclear materials. It is essential that institutional generators obtain and retain certifications of nuclide inventory and activity, as well as complete descriptions of the materials purchased and used in the fabrication of sealed sources, radiopharmaceuticals and instrumentation containing nuclear materials. Furthermore, such organizations should maintain records of the receipt, use and retirement of nuclear materials, making it possible to trace and identify these materials and to calculate activity at the time of their submission to conditioning facilities, as well as to accurately derive the chemical composition and chemical attributes (reactivity, corrosivity, flammability, toxicity) of the items as submitted for characterization. Additionally, operating procedures should provide sufficient information to determine what operational use, if any, may have contaminated the item in a manner that requires chemical stabilization or treatment as part of the conditioning process. Finally, procurement and receipt inspection documents and operating procedures should be complete in a manner demonstrating evidence of the chain of custody so that the conditioning facility can be confident that process knowledge is valid and complete. It should be noted that deficiencies in such documentation require further assay and/or analytical characterization by the conditioning facility [23], for which the institutional waste generator will be legally responsible.

The following are the specific minimum requirements for records:

(1) *Sealed sources*

Copies of procurement documents, manufacturer's certificates of assay, and manufacturer's drawings or lists of construction materials. All sources should be inventoried at least on an annual basis, or in accordance with other applicable regulatory requirements. The records should be appropriately secured.

Source records should be maintained and updated according to Ref. [36]:

- At the time of the routine inventory;
- Whenever the recorded parameters change;
- Whenever sources are transferred.

The records should include the following particulars:

- Location of the source;
- Radionuclide;
- Activity on a specified date;
- Serial number or unique identifier;
- Physical form;
- Source use history (e.g. logging of all source handling operations);
- Receipt, transfer or disposal of the source.

A package/drum record should be issued for each conditioned disused source package (drum), including the main data on the package. Examples of package/drum form and storage record forms for conditioned disused sealed radioactive sources are provided in Ref. [34].

(2) *Radiopharmaceuticals or other radionuclides in solution*

A manufacturer's certificate of radionuclide concentration (by mass or activity) and chemical composition, measured volume of solution remaining, description of pretreatment (solidification) performed, if any, procurement documents including bill of lading or other dated receipt documents.

(3) *Equipment containing radioactive sources*

Procurement documents, detailed manufacturer's drawings on fabrication and configuration, manufacturer's certification of assay or activity, user's procedures or drawings showing where and how the instruments were employed.

(4) *Radioactive materials produced through use of target materials in accelerators or research reactors*

Description of target base material, and either a detailed description of the production process (including dates, duration of irradiation and irradiation field) or, preferably, a certified measurement of activity and nuclide inventory.

For all of the above, detailed descriptions of any pretreatment, details of the packaging configuration as submitted for conditioning, and specific data required by Ref. [11] for transport to the conditioning facility must also be prepared and must be:

- (i) Provided to the conditioning facility;
- (ii) Retained as generator records; such records should be handled by the organization in accordance with the guidance provided in Section 4.3.5.

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GLOSSARY

Definitions marked with an asterisk are taken from Ref. [8]; others are additional definitions extracted from various sources and are applicable only for the purposes of this publication.

audiovisual records. Records in pictorial or aural form, including still and motion pictures, graphic materials such as posters and original art, audio and video recordings, and combinations of media such as slide-tape productions.

authorization basis. A facility's authorization basis is that combination of safety related hardware and administrative programmes relied on in facility safety analyses and performance assessments to prevent, detect or mitigate postulated accidents so that projected releases remain within limits authorized for unrestricted operation.

custody. Guardianship or control of records, including both physical possession (physical custody) and legal responsibility (legal custody), unless one or the other is specified.

disposition. The action taken when records are no longer needed for current activities. Dispositions may include destruction of non-permanent records or transfer of permanent records to a permanent archive facility.

document. Recorded information regardless of physical form or characteristics; often used interchangeably with record.

file. Usually an accumulation of records or non-record materials arranged according to a plan; in electronic records an organized collection of related data usually arranged into logical records that are stored together and treated as a unit.

hard copy.

- (a) Recorded information copied from a computer onto paper or some other durable surface such as microfilm. It is to be distinguished from a temporary image on a display screen and from the electronic information on a magnetic tape or disk (diskette) or in the computer's main memory.
- (b) Recorded information copied from microfilm onto paper and made readable without a special device.
- (c) A paper record that may later be filmed or digitized.

index. A listing of records that includes such information as document identification number, title, date, revision, author(s), organization responsible for the record, associated facility, process, waste form or package, location in the storage facility, media type, size and intended disposition. Indexing systems are generally designed to allow retrieval of records by multiple attributes (title, subject, document number, waste form, waste package number, etc.).

medium. The physical form of recorded information. This includes paper, film, disk, magnetic tape and other materials on which information can be recorded.

microfiche. A card sized transparent sheet of film with miniaturized images (micro-images) arranged in a grid pattern, usually containing a title readable without a magnifying device.

microfilm.

(a) Raw (unexposed and unprocessed) fine grain, high resolution film suitable for use in micrographics.

(b) Fine grain, high resolution film containing micro-images. (See also silver gelatin film.)

output records. In electronic records, information generated by a computer and placed on an outside medium such as paper, microform or an electronic storage medium.

preservation.

(a) Provision of adequate facilities to protect, care for or maintain records.

(b) Specific measures, individual and collective, undertaken to maintain, repair, restore or protect records.

process knowledge. Operating procedures, procurement documents, assay reports and chemical analyses that provide the basis for understanding the composition of as-generated ('raw') waste.

records management. The planning, controlling, directing, organizing, training, promoting, and other managerial activities related to the creation, maintenance and use, and disposition of records to achieve adequate and proper documentation.

records management programme. A planned, coordinated set of policies, procedures and activities needed to manage recorded information, encompassing the creation, maintenance and use, and disposition of records, regardless of medium.

records schedule. A document providing mandatory instructions for what to do with records (and non-records materials) no longer needed for current business, with provision of authority for the final disposition of recurring or non-recurring records. Also called records disposition schedule, records control schedule, records retention schedule, or schedule.

scheduled records. Records whose final disposition has been approved.

silver gelatin film. In microform records, archival quality film containing images produced by using light sensitive silver halide crystals suspended in a gelatin emulsion. Silver gelatin film should be distinguished from dry silver film, which is not of archival quality.

software dependability. The capability of software to deliver a specified service; reliability, maintainability, safety and security are attributes of dependability.

source documents. Documents containing images and/or data entered into a microform or electronic records system; also called source records.

transfer. The act or process of moving records from one location to another.

***waste container.** The vessel into which the waste form is placed for handling, transport, storage and/or eventual disposal; also the outer barrier protecting the waste from external intrusions. The waste container is a component of the waste package. For example, molten HLW glass would be poured into a specially designed container (canister) where it would cool and solidify.

***waste form.** Waste in its physical and chemical form after treatment and/or conditioning (resulting in a solid product) prior to packaging. The waste form is a component of the waste package.

***waste package.** The product of conditioning that includes the waste form and any container(s) and internal barriers (e.g. absorbing materials and liners), prepared in accordance with the requirements for handling, transport, storage and/or disposal.

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