

**WASTE PACKAGE SPECIFICATION AND
GUIDANCE DOCUMENTATION**

**WPS/850: Waste Package Data and Information
Recording Specification:
Explanatory Material and Guidance**

**March 2008
Number: 9699298**

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WASTE PACKAGE SPECIFICATION AND GUIDANCE DOCUMENTATION

**WASTE PACKAGE DATA AND INFORMATION RECORDING SPECIFICATION:
EXPLANATORY MATERIAL AND GUIDANCE**

This document forms part of a suite of documents prepared and issued by the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA).

The Waste Package Specification and Guidance Documentation (WPSGD) provide specifications and guidance for waste packages, containing Intermediate Level Waste and certain Low Level Wastes, which meet the transport and disposability requirements of geological disposal in the UK. They are based on, and are compatible with, the Generic Waste Package Specification (GWPS).

The WPSGD are intended to provide a 'user-level' interpretation of the GWPS to assist Site License Companies (SLCs) in the early development of plans and strategies for the management of radioactive wastes. To aid in the interpretation of the criteria defined by the WPSGD, and in their application to proposals for the packaging of wastes, SLCs are advised to contact RWMD at an early stage.

The WPSGD will be subject to periodic enhancement and revision. SLCs are therefore advised to contact RWMD to confirm that they are in possession of the latest version of any documentation used.

WPSGD DOCUMENT NUMBER WPS/850 - VERSION HISTORY		
VERSION	DATE	COMMENTS
WPS/850/01	March 2006	Aligns with GWPS (Nirex Report N/104) as published June 2005
WPS/850/02	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

This document has been compiled on the basis of information obtained by Nirex and latterly by the NDA. The document was verified in accordance with arrangements established by the NDA that meet the requirements of ISO 9001. The document has been fully verified and approved for publication by the NDA.

CONTENTS

1	INTRODUCTION	1
2	BACKGROUND	1
2.1	The Concept of Geological Disposal	1
2.2	The Generic Waste Package Specification	2
2.3	The Assessment of Packaging Proposals	3
3	AIMS	3
4	IMPLEMENTATION	6
4.1	Responsibilities of the Waste Packager	6
4.2	Information to describe the waste package	6
4.3	Generic information	8
4.4	Batch specific data	9
4.5	Package specific data	9
4.6	Administrative information	10
5	GUIDANCE FOR WASTE PACKAGE DATA AND INFORMATION	10
5.1	Waste package identifier	10
5.2	Waste	10
5.3	Waste container	11
5.4	Encapsulant, capping and conditioning material	12
5.5	Wasteform formulation	12
5.6	Process conditions	13
5.7	Nature of the waste package	14
5.8	Waste package radionuclide inventory	15
5.9	Wasteform component inventory	16
5.10	Waste package properties	23
5.11	Waste Product Specification	25
5.12	Waste package history	25
5.13	Criticality safety	26
5.14	Administrative	27
5.15	Transport	27
5.16	Nuclear Material Accountancy and Safeguards	27
5.17	Hazardous wastes	28
	REFERENCES	36

1 INTRODUCTION

The Radioactive Waste Management Directorate (RWMD) 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 NDA is currently working with Government and stakeholders through the Managing Radioactive Waste Safely (MRWS) consultation process to plan the development of a Geological Disposal Facility (GDF).

As the ultimate receiver of wastes, RWMD, acting as GDF implementer and future operator, 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 RWMD 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) which 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.

This document has been produced to provide explanatory information and guidance on the interpretation of the *Waste Package Data and Information Recording Specification, WPS/400*, which provides a concise statement of the waste package data and information recording requirements specified in the GWPS.

2 BACKGROUND

2.1 The Concept of Geological Disposal

A key aspect in the production of standards and specifications for packaged waste is the definition of a disposal system which encompasses all stages of the long-term management of waste from retrieval through to final disposal.

In line with the MRWS consultation process, RWMD are continuing to develop concepts for the geological disposal for higher activity wastes which include ILW, and certain LLW not suitable for disposal in other LLW facilities. It is envisaged that the geological disposal of such wastes would comprise a number of distinct stages including:

- the retrieval and conditioning of the waste to create disposable waste packages, usually at the site of waste arising;

¹ Specific references to individual documents within the WPSGD are made in this document in italic script, followed by the relevant WPS number.

WPS/850/02
March 2008

- a period of interim surface storage, also at the site of arising;
- transport of the waste packages to a GDF;
- transfer of waste packages underground and emplacement in disposal vaults;
- a period of monitored storage underground, during which retrieval by relatively simple means would be feasible;
- back-filling of the disposal vaults, followed by eventual sealing and closure.

The timing and duration of each stage would depend on a number of criteria, including the geographical location and host geology of a GDF as well as the disposal concept selected for implementation.

The Phased Geological Repository Concept (PGRC) [2], has been developed as one manifestation of geological disposal and has been adopted as the reference concept for the purposes of establishing packaging standards. The PGRC is supported by a suite of safety, security and environmental assessments intended to demonstrate that this concept will provide safety to workers and the public and provide the necessary level of environmental protection.

The safety philosophy adopted in the PGRC is one of containment of radionuclides by multiple barriers, of which that provided by the waste package is a key component. Included in these barriers are those provided by the waste package, which itself can be considered as two independent but complimentary barriers, the waste container and the wastefrom, each of which plays an important role in the containment of radionuclides.

As the MRWS consultation process continues it is anticipated that the siting process, based on expressions of interest from volunteer communities, may lead to the identification of sites for investigation as to suitability to host a GDF. The disposal concept design and safety case will be developed to suit the specific characteristics of the site and packaging standards will be updated to reflect the new circumstances as appropriate.

2.2 The Generic Waste Package Specification

A major area of the RWMD's work is the provision of advice to the packagers of radioactive waste in the UK, by way of the definition of packaging standards and the assessment of individual waste packaging proposals against those standards.

The primary document that defines packaging standards for ILW is the GWPS [1]. Derived from the PGRC and its associated generic documentation, which comprise the system specifications and safety assessments that define the PGRC, the GWPS provides the basis for assessing the suitability of waste packages containing ILW for disposal in a GDF.

The packaging standards defined by the GWPS are generic in two respects in that they are:

- derived from a full consideration of all future stage of long-term waste management; and
- independent of the location of the site of a GDF, which could be implemented at a range of different sites within the UK, representing a range of geological environments.

The format of the GWPS is to define:

- general requirements that are applicable to all waste packages;
- a range of standard waste containers;
- specific requirements for the standard waste package design that are created using the standard waste containers;
- requirements for the conditioned wasteforms that are placed into containers;
- requirements for quality management and for the creation and maintenance of records about each individual waste package.

The GWPS therefore defines the performance requirements for the two barriers to the release of radionuclides provided by the waste package, the waste container and the wasteform, against which the overall performance of waste packages can be assessed.

2.3 The Assessment of Packaging Proposals

Since the mid-1980s, waste producers in the UK have made significant investment in waste retrieval and packaging plant as a means of ensuring that such wastes are rendered passively safe and suitable for disposal. Historically Nirex was responsible for the assessment and endorsement of the suitability of packaging processes for this latter need, originally by way of the 'Letter of Comfort' assessment process. Over the ensuing two decades the Letter of Comfort process has developed and matured to a point that the assessments undertaken were established on a more structured footing with detailed advice being issued to waste producers highlighting further information needs, or need for further development and/or research before a Letter of Comfort could be issued. The assessment process was also modified to integrate better with the implementation of packaging plant projects, with staged interactions occurring at a number of stages before active operation of a packaging plant commenced. The status of the assessment process was strengthened in January 2004, when support was provided by UK nuclear regulators, and it was recognised within improved regulatory arrangements for nuclear licensed sites [3]. This was accompanied by significant changes to the assessment process which was renamed the 'Letter of Compliance' assessment process, a full description of which can be found in *Guide to the Letter of Compliance Assessment Process, WPS/650*.

In April 2007 Nirex was dissolved and its responsibilities assumed by RWMD. This included the role of assessing and endorsing nuclear site operators' waste packaging proposals through the LoC assessment process.

In undertaking LoC assessments RWMD determines whether wastes, when packaged, will have characteristics compliant with plans for transport to, and operations at a GDF, and ultimately whether the wastes could be accommodated within a GDF long-term post-closure safety case. The main output of a LoC assessment is an Assessment Report which may be accompanied by the issue of a LoC endorsing the packaging proposal. In line with the recently updated regulatory guidance [4] such endorsement is now seen by the regulators as an important component of the operator's Radioactive Waste Management Case.

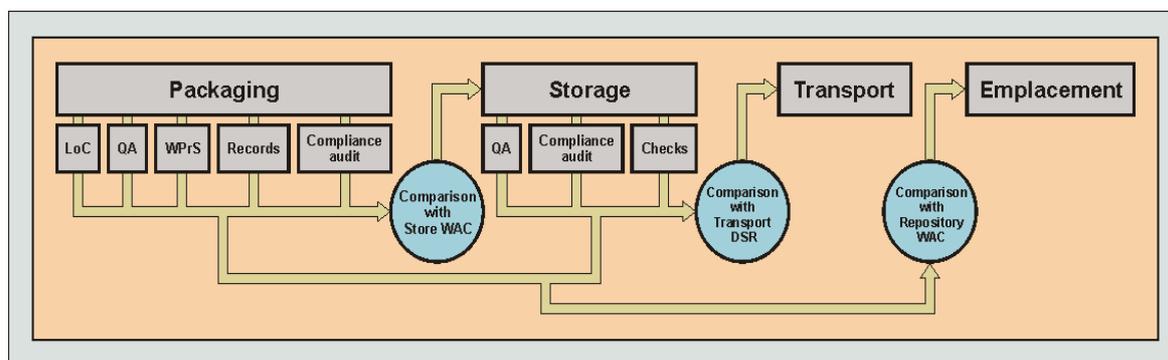
3 AIMS

This document is not intended to be prescriptive but instead provide clear guidance on the need to establish a data recording system that is both tailored to the waste management activities and the anticipated information requirements of future custodians of the waste package.

The Data Requirements section of the GWPS identifies the information that would need to be made available by the waste packager to support all future stages of the long-term management of waste packages, including disposal in a GDF. Additional information must continue to be generated throughout the various periods of the management of waste packages, but the reliability of the data at any moment rests upon the quality and integrity of all earlier data. The process must therefore begin with the design and production of each individual waste package.

RWMD therefore requires that waste packagers establish a data recording system for acquiring, recording and subsequently managing information for each waste package to such that it may be assessed against the requirements for safe and cost-effective handling, transport, storage and eventual disposal. What needs to be recorded, therefore, is information that can be used to establish, infer or predict package properties and performance under all relevant circumstances. Ultimately, this information may be used to demonstrate conformance with future Waste Acceptance Criteria (WAC) for transport and a GDF, as illustrated in Figure 1.

Figure 1 Role of the Data and Information Recording in Waste Acceptance



Waste Package Data and Information Recording Specification, WPS/400 is based on the Data Requirements section of the GWPS, both of which being derived from an understanding of the criteria that are important to waste package performance and safety over the extended period encompassed by all of the periods of waste management including disposal in a GDF. The recognised uncertainty of these future requirements means that a broad-based approach is necessary.

The relevant information is listed in WPS/400, where a number of *data classes* have been defined, guidance on identification and acquisition of information for these data classes is given in Section 5. This information would produce a data record that would:

- describe the physical, chemical and radionuclide content of a package thus providing an accurate and trustworthy record of the nature and contents of the package;
- identify and define package properties and performance relevant to future management options;
- provide sufficient *enabling data*² to allow the radionuclide inventory to be extended as required (through the application of suitable extrapolation methods);

² Terms in this document that are intended to have a specific, defined meaning are indicated in italic script at their first usage, and defined in the Glossary.

- provide sufficient enabling data to predict the likely evolution of the package with time, the effect of interactions with other packages and disposal system components and the effect of environmental conditions on package integrity.

To facilitate the development of a data recording system, it is suggested that the means of recording information and its subsequent management may be regarded as falling into two broad categories:

- *recorded information* – (hard) information directly associated with a package that would accompany the package either physically or electronically, and to which access is likely to be needed through all periods of waste management;
- *traceable information* – (contextual) information or documents referenced from a data record. Examples might include manufacturing specifications, LoC submissions (and the resulting LoC and Assessment Report), *Waste Product Specifications* (WPrS) and quality records. The waste packager may decide that traceable information is managed separately from the recorded information.

This categorisation is purely illustrative and the methods used to record and manage the package information are at the discretion of the waste packager. This guidance document provides suggestions concerning management procedures that may be appropriate, but it is not intended to be prescriptive. Hence, the identification of the appropriate means of recording the various parts of a data record is an important aspect of the tailoring of the data recording system.

It should be noted that the purpose of this document is to provide guidance to assist waste packagers in satisfying the data recording requirements, as specified in *WPS/400*, and that it is not intended to address the implementation of data recording systems, such as the British Radwaste Information Management System³ (BRIMS) [5], or to provide guidance on the long-term maintenance of recorded data⁴.

³ BRIMS has been developed by the UK nuclear industry and its regulators to provide a common tool for the recording of a wide range of radioactive waste-related information. The objectives of BRIMS project can be summarised as:

- i) the provision of an electronic tool that meets the rigorous demands for both the preservation of, and access to, radioactive waste-related information over the long-term;
- ii) the provision of continuing and comprehensive technical support to users of the tool; and,
- iii) facilitating the production of UK radioactive waste inventories.

BRIMS development is guided by representatives of waste custodians, industry regulators and other waste management organisations. It can be made available for use on a local area network (LAN) or as a stand alone version to any waste custodian organisation. Further information on the tool can be found in the BRIMS Strategy Document [5].

⁴ Guidance on this significant aspect of data recording can be found in *Long-term Management of Information and Records: Explanatory Material and Guidance WPS/870*.

4 IMPLEMENTATION

4.1 Responsibilities of the Waste Packager

The waste packager is responsible for the development of a data recording system that would establish an information capture strategy thus creating the data record for each *waste package*. However, the range of information that would need to be recorded for each distinct waste package will be unique and the development of a tailored system may be required for each *waste type* and packaging campaign.

Information would be created over the entire lifetime of the waste package, from process conception, through process development, waste package production, storage, transport and ultimately disposal. The main opportunities for defining and acquiring information are summarised in Figure 2, which illustrates the various stages in packaging of a typical waste type (although the illustrated opportunities should not be regarded as prescriptive). The figure clearly shows that the various data classes are likely to be populated at different stages.

Although much relevant information would arise during the development of the packaging process, information acquisition is likely to continue into the waste package production stage and beyond. The information acquired after production would generally focus on storage conditions, interim movements and package evolution.

The assessment by RWMD of packaging proposals would assist in the development of the data recording system through discussion and agreement of the particular data recording requirements. These discussions may lead to the identification of areas where further system development would be beneficial. The LoC submission documentation compiled by RWMD is itself a valuable source of traceable information for waste packages (for example as a means of recording arguments and analogies, referencing research and defining methods) and would be managed accordingly.

4.2 Information to describe the waste package

It is recognised that the information associated with a waste package may take a number of different forms and that the various data classes may be populated by different means. However, four general categories of information may be identified, as follows:

- information that applies to the waste type as a whole, in particular the documents that define the origin of the waste, storage and retrieval methods, the packaging process, the results of a *development programme*, *manufacturing specifications* and the properties of the waste package (*generic information*);
- information relating to a batch of packages, for example manufacturing records for a batch of containers and assay results for package components that apply to a batch of waste (*batch specific data*);
- information for individual waste packages as manufactured, primarily required to demonstrate conformance with specifications or *limits* (*package specific data*);
- other information required to fulfil particular regulatory and administrative requirements (*administrative information*).

The relationships between these categories of information are illustrated in Figure 3.

Figure 2 Opportunities for the Definition and Acquisition of Waste Package Data.

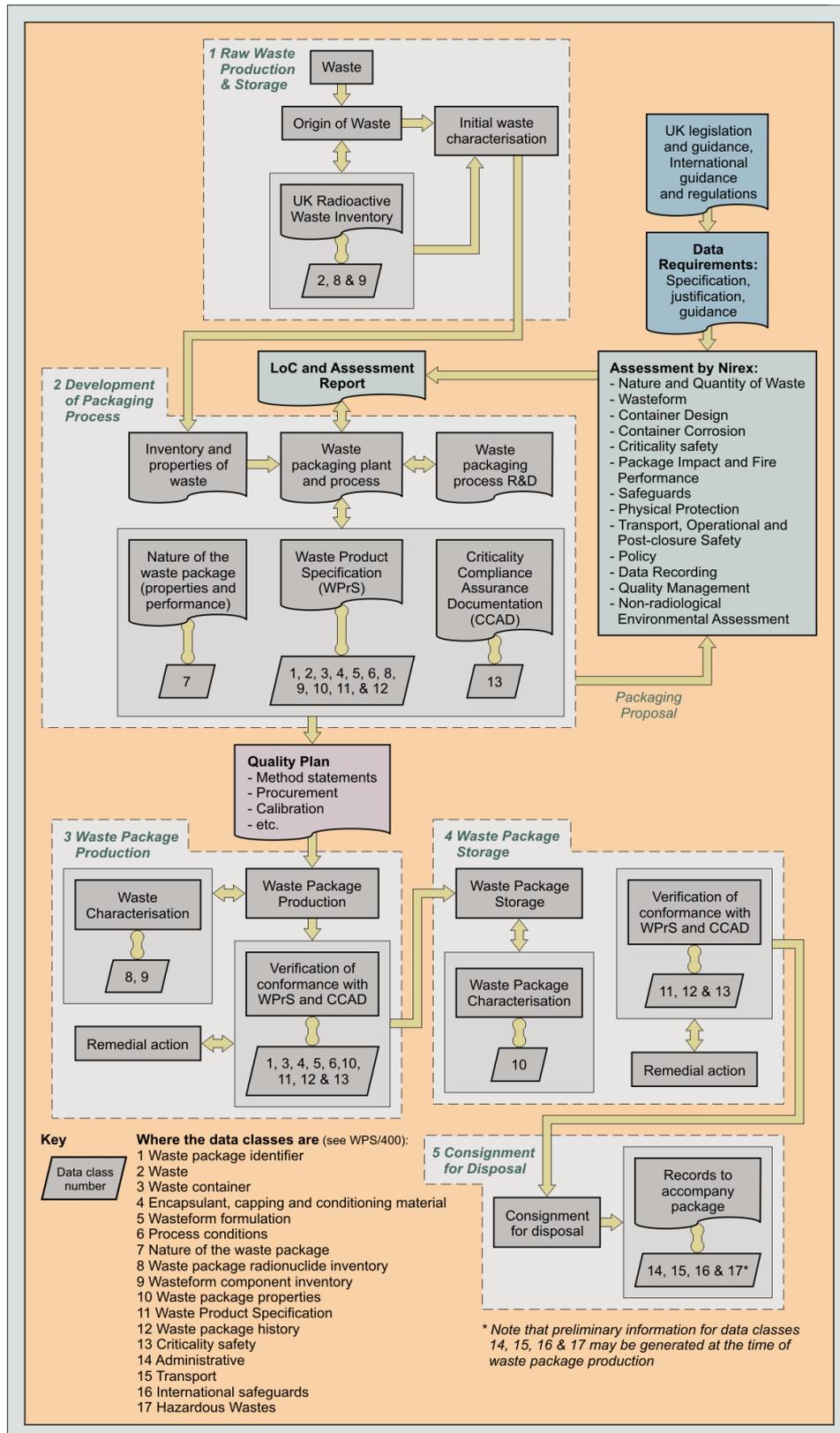
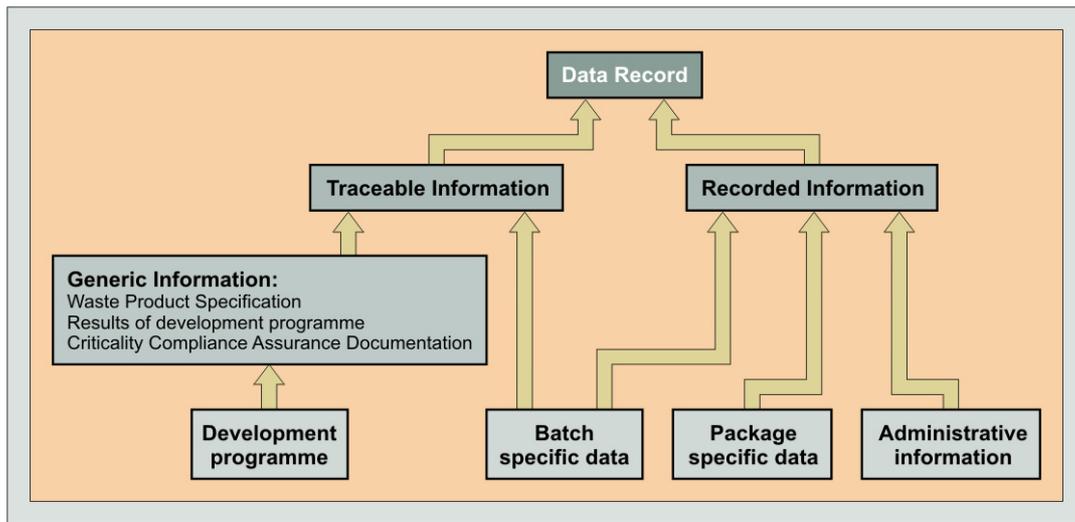


Figure 3 Categories of Information



In general, generic information and any batch specific data may be recorded and retained as traceable information. In contrast, the package specific data and administrative information generally would be retained as recorded information specific to each package.

Information relating to most aspects of *product quality* would include both generic information and package specific data. This would be the case where a limit on a quantity is imposed (recorded as generic information and applying to all packages of the type) and conformance data is recorded to show the conformance of the individual package with that limit (recorded as package specific data). The generic information and conformance data are to be recorded as separate data classes in a data record.

It may be appropriate to record information either at the package scale or on a broader basis. For example, if the variability in the quantity of a component of the waste is small or not significant, it may be appropriate to define an average value for all relevant packages. Such circumstances should be identified by the waste packager, agreed with RWMD and subsequently included in the tailoring of the data recording system.

The four categories of information are considered further below.

4.3 Generic information

The development of a waste packaging process would take due consideration of the relevant properties of the complete waste package during all periods of their management. This development programme should provide:

- evidence of waste package properties and performance;
- the relationship between these and the nature and quantity of waste;
- encapsulation materials used in the creation of a waste package;
- waste conditioning and packaging materials and processes.

In this manner, the parameters that are of significance to product quality would be identified. In addition, those parameters that do not significantly influence product quality also may be identified, thereby providing a justification for not controlling or recording them.

The results of the development programme would form an important component of the data record. This information is likely to be retained as traceable information and ideally would be referenced from the data record or from other documents such as the WPrS.

The WPrS would define the intended product resulting from a waste packaging process. It provides a bridge between the development programme and the process as it is implemented and should identify any limits to be met during processing. It is recommended that a separate WPrS be prepared for each waste type and packaging method to provide greater clarity. The important link between the WPrS and package specific data (discussed in Section 4.5) should be recognised. The WPrS should take the form of traceable information referenced from the data record.

The *Criticality Compliance Assurance Documentation* (CCAD) is required to demonstrate how the safe fissile mass limits, defined either by package specific criticality safety assessments (CSA) or by the relevant fissile material screening level, would be met. Criticality safety may impose more stringent limits or recording requirements than those derived from general product quality issues. Verification of conformance should also be addressed by the definition of the appropriate conformance data to be recorded and the method of deriving that information. The CCAD should take the form of traceable information referenced from the data record.

The generic information also should include information on how the waste was created, stored and retrieved. This information would provide important enabling data.

4.4 Batch specific data

It is recognised that some information may apply to several packages constituting a subset of the whole. Examples include manufacturing and purchasing information for a batch of containers and analytical data pertaining to a quantity of waste that would be distributed between several packages. Such batch specific data may be duplicated in individual sets of recorded information or referenced as traceable information. The appropriate means of recording such information would depend on the nature of the information and is at the discretion of the waste packager. RWMD would be prepared to discuss and possibly advise on the optimum management arrangements for preserving such information.

4.5 Package specific data

Package specific data generally constitute information that is unique to each package. This may include identification of the package, information required to demonstrate conformance with limits (conformance data) and more general information on the nature and contents of the package. The required information should be obtained through suitable *data acquisition systems*. These may include measurements made either on the constituent parts of the waste package, perhaps during package production, or on the waste package itself following storage. Of particular importance are the *process records* produced during packaging.

Decades may elapse between the packaging of the waste and its ultimate disposal. Consequently, the evolution of the package may be of significance. To demonstrate that the waste package would continue to conform to the requirements for handling, transport, storage and potential disposal, it would be necessary to maintain a chronological history of the package, including storage duration, environmental conditions, results of periodic inspection and any significant events to which the waste package had been exposed (i.e. minor impacts, excursions in storage environment conditions). This would contribute to

the enabling data for any future assessment of the package and to any research and development intended to determine likely long-term evolution.

4.6 Administrative information

In addition to those data classes discussed above, some information is required to fulfil administrative and regulatory requirements, generally those related to transport or disposal of the waste. Such information should accompany the waste package and populate some of the data classes. Further discussion is provided in the relevant parts of Section 4. In general, this information would not be required until the time of consignment of the waste for long-term storage or disposal.

5 GUIDANCE FOR WASTE PACKAGE DATA AND INFORMATION

Detailed explanatory material and guidance on the interpretation of the individual data classes is given below. To facilitate understanding, some sub-sections include a brief definition of the required contents of the data class; a summary explanation of why particular information is required and a discussion of the means by which the information might be obtained.

In all cases, it is intended that the guidance is not prescriptive. Indeed, the necessary information would vary between different waste types and therefore such prescription is not practical. It should be recognised that the primary responsibility for identifying the means for obtaining information rests with the waste packager. However, RWMD can advise on, and where appropriate, formally endorse the adequacy of proposed arrangements through the LoC process. Where necessary, the waste packager and RWMD may hold informal discussions to aid the development of the data recording system.

5.1 Waste package identifier

The waste package identifier (as defined in *Specification for Waste Package Identification System, WPS/410*) is the primary means of identifying a waste package and linking it to the data record. Individual operational facilities are allocated a unique series of numbers, within the range of numbers available, that would clearly link an individual waste package with its origin.

Some container furniture, such as the stillages used for handling and stacking 500 litre Drum waste packages are also given unique identifying numbers. Where appropriate, these also should be included in data records.

5.2 Waste

5.2.1 Description of raw waste

A description of the raw waste is required. A simple description such as 'Fuel Pond Sludge' or 'Plutonium Contaminated Material (PCM) from Mixed Oxide (MOX) Fuel manufacture' would suffice. This description could be provided within the WPrS. Where a collection of waste streams of the same general origin may have different characteristics, some distinction between the individual streams should be included in the description, for example by reference to 'Tanks 1 to 5'.

5.2.2 Relevant UK Inventory waste stream identifier

The relevant UK Radioactive Waste Inventory waste stream identifier should be supplied where this is available. This would facilitate tracking of identified waste to disposal. It could be provided within the WPrS. Any use of or reference to UK Inventory information would require an accompanying reference date and issue of the UK Inventory to enable accurate interpretation, as inventory identifiers and waste stream descriptions can change over time.

5.2.3 Origin of the waste

A simple description of the process that gives rise to the waste should be provided. It could be provided within the WPrS. Alternatively, the information may be traceable through the UK Inventory Identifier. In cases where streams are combined for packaging or the UK Inventory Identifier covers an amalgamation of streams, information held in the UK Inventory may not be sufficient. In such cases, a clear description of the origins of all waste components should be provided.

5.2.4 Identity of storage facility for raw waste

The identity of the storage facility containing the raw (unconditioned) waste should be provided as this would facilitate the tracking of the waste to its ultimate disposal. Where appropriate, processes that indirectly change the waste compositional inventory (for example, a pond water change that removes soluble caesium) should be described. This type of information could be provided in the WPrS or as recorded information.

5.3 Waste container

The container is an important component of the waste package and may determine, or at least strongly influence, overall package performance and product quality. The design and development of containers is an important part of the development programme and data records should provide information about the process.

The data records should provide a description of the container. This information may be provided through reference to a manufacturing specification that may be separately managed. A general description and references to the detailed specifications of the waste container also may be included in the WPrS. In addition, individual data records should include conformance data to show that each container complies with the manufacturing specification. This may be provided by manufacturing or procurement records.

Amongst the information that might be provided is:

- manufacturing specification, including detailed design drawings;
- material specifications and certificates;
- manufacturing process controls;
- dimensions, inspection records, compliance details, acceptance test results and concession forms;
- container transport, delivery and storage conditions.

In some cases, the container may be partially manufactured during the packaging of waste, for example where a lid is cast over the wasteform in a concrete container. Where

this is the case, a manufacturing specification for this process should be recorded or referenced.

RWMD has developed specifications for standard waste containers. Although these specifications may be cited in data records, these should be supplemented by more detailed manufacturing specifications.

5.4 Encapsulant, capping and conditioning material

Principal constituents of the wasteform are the waste itself and the materials used to pre-condition, encapsulate or immobilise and cap the waste. The choice of conditioning, encapsulating and capping materials will impact on the product quality. An important aim of the development programme would be to establish the suitability of such materials. Consequently, information on the materials selected should be recorded as generic information.

The information required may include the following:

- description of the nature of the materials;
- details of the various components or composition of the materials;
- references to Quality Assurance (QA) documentation and details of existing specifications (for example British Standards and manufacturer's specifications) and additional specifications developed by waste packagers;
- relevant physical properties, including acceptance testing and pass criteria to be met prior to use;
- the results of quality checks undertaken on completion of the packaging operations;
- material storage conditions and any limitations on storage time.

The required materials, and any relevant specifications, should be identified during the development programme. This information also should be included in the WPrS. However, attention should be paid to the level of detail provided to ensure that materials are not over-specified.

Suitable conformance data should be included in the data records and the necessary recording of the quantities of these materials is discussed in Section 4.9.3. Process records for individual packages would commonly act as conformance data for this aspect of the WPrS. Data records should include sufficient information to allow materials to be traced to their source. Where acceptance tests are required, the results of such tests also should be recorded or referenced.

5.5 Wasteform formulation

The wasteform formulation should define the necessary quantities of the principal constituents of the wasteform; that is the quantities of the constituents of the wasteform, and is considered to be generic information. The definition of the compositions of the various constituents, with the exception of the waste itself, is discussed in Section 4.4. The recording of the composition of the waste itself is considered in Sections 4.8 and 4.9. The constituents might include, for example:

- raw waste;
- chemical pre-conditioning material and process materials;

- immobilisation material or encapsulant (cement-based or otherwise);
- capping grout.

The quantity of each constituent may be specified in any manner that is appropriate to the process employed. Typically, these quantities may be expressed as the absolute mass or volume and, in some cases, the relative quantity of the constituent.

The formulation should include the definition of a formulation envelope, that is the allowed range of values for each constituent. This is necessary as quantities cannot be delivered with complete accuracy by a process and practical concerns may require variations in the quantities used. The formulation envelope should define the range of wasteform compositions for which product quality would be acceptable. In practice, a comparison of the inventory of package components (discussed in Section 4.9.3) with the formulation (and formulation envelope) would provide a means of demonstrating that a suitable product has been manufactured.

An appropriate means of recording the desired formulation is the WPrS, including suitable references to the results of the development programme. These results should demonstrate the linkage between the formulation and product quality. The formulation should be specified to a suitable accuracy. This should be established through an understanding of the sensitivity of product quality to the quantities of the constituents.

5.6 Process conditions

Process conditions are the actual conditions under which a waste package is manufactured. For example, it may be necessary to record, depending on the nature of the wasteform:

- component temperatures;
- method and rate of component addition;
- mixing speeds and times;
- in-process movement times;
- process verification steps.

The way in which a wasteform is manufactured and the process conditions under which it was produced may have an important influence on product quality. The process records enable confirmation that all important conditions have been met. This would provide confidence that the characteristics and properties of a waste package demonstrated by the development programme may also be attributed to the waste packages produced.

The conditions under which a wasteform is produced will determine, to a large extent, the properties and characteristics of that wasteform. The range of acceptable process conditions and the accuracy with which these should be controlled should be established in the development programme and by evaluation of trial products. It is usual that a practical envelope of process conditions is defined and verified during plant commissioning.

Any limits on the process conditions necessary to guarantee acceptable performance should be included in the WPrS. Conformance data should be sufficient to demonstrate conformance with any such limits.

WPS/850/02
March 2008

The process information to be recorded will vary for different processes, both in scope and accuracy. For example, for an in-drum mixing process based on cement, it may be necessary to specify and demonstrate conformance with requirements for:

- waste and cement temperature;
- cement addition rate, position and duration;
- paddle design and mixing speed;
- duration of mixing.

For solid waste encapsulation using a cement grout or the casting of a grout annulus around the waste, a different set of specified requirements may arise, for example:

- grout mixer type and mixer speed;
- cement addition rate and duration;
- water and cement temperature;
- mixing duration;
- hold-up time before waste infilling;
- fluidity of the grout;
- rate and duration of infilling.

Similarly, any pre-treatment of the waste may impose additional process constraints and therefore require that further information be recorded. In other cases, physical parameters such as supercompaction force and degree of compaction may be identified as significant process information.

The basis for relevant part of the data records is likely to include process records and product quality or conformance data generated during development programmes. It is also important that references to support the acceptable range of process conditions should be recorded, perhaps in the WPrS or in the packaging submissions.

5.7 Nature of the waste package

The function of the waste package is to allow the waste to be stored, handled and potentially disposed of safely and efficiently. It is therefore important to establish sufficient confidence that product quality is such that these requirements would be met. Confidence is usually established through a development programme and the definition of a WPrS based on the results of that programme (see Figure 3).

The 'nature of the waste package' is a statement of the expected properties and performance of the waste package, when manufactured according to the specification. The required information should provide evidence that all relevant properties and performance characteristics of the waste package are consistent with the product quality requirements identified in the *Waste Package Quality Management Specification, WPS/200*.

The range of properties to be considered will depend on the nature of the waste and the sensitivity of package performance to variations in composition and processing. Waste packagers therefore should identify the relevant properties of the wasteform and design the development programme accordingly. Relevant properties may include:

- demonstration of conformance with the requirements for performance under impact and fire accident conditions;

- thermal conductivity;
- voidage;
- thermal, chemical, radiation and mechanical stability;
- corrosion rates of waste package materials;
- gas generation and migration;
- mobility of radionuclides and aqueous migration properties;
- compatibility with alkaline disposal environment;
- stability of filters and seals.

As a waste package may be manufactured within a formulation envelope under a range of process conditions (see Sections 5.5 and 5.6), the recorded information should reflect the breadth of products that may be produced.

It is unlikely that substantial information on wasteform properties need be generated during packaging. However, confirmatory tests may be required for some processes and specific measurements are discussed in Section 5.10.

Product quality information may be re-stated in the recorded information or, perhaps more commonly, a reference to traceable information should be recorded. Where information is re-stated, it should be made obvious whether the quoted values are intended as examples of typical values, expected ranges of values based on experimental observation or necessary limits based on argument or observation. References are likely to be cited in documents such as the WPrS or packaging submissions and associated documentation.

5.8 Waste package radionuclide inventory

The radionuclide inventory associated with a waste package is a listing of the nature and quantity of the radioactive species present in that package. The radionuclide inventory is a fundamental data class that enables the significance of the waste to be judged. Realistic and justifiable package inventories are also required to ensure the integrity of the accumulated inventory, and its distribution, for future stages of waste management.

In practice, the inventory should be limited to the *significant radionuclides*, potentially including enabling data. This would avoid the need to report small quantities of short-lived or otherwise insignificant radionuclides. It is the responsibility of the waste packager to develop the list of significant radionuclides for a waste type, in consultation with RWMD. To aid in this process and to understand the significance of radionuclide inventories, the concept of *Guidance Quantities* (GQ) has been developed by RWMD [6]. The GQ for a particular radionuclide is derived from an assessment of all stages of waste package management and indicates the quantity considered potentially significant. A simple comparison with GQ values provides initial guidance as to those radionuclides that should be included in data records. However, further guidance should be sought from RWMD to ensure that the inventory to be recorded is comprehensive.

The physical or chemical form of a radionuclide may also be significant and, if this is the case, this should be recorded. Particular examples include potentially gaseous species (for example tritium dissolved in metals or corrosion products) and particulate material. The latter is discussed further in Section 4.9.3.

The quantities of some radionuclides may be limited in some packages. Such radionuclides might include those giving rise to penetrating radiation (i.e. Co-60),

WPS/850/02
March 2008

gaseous radionuclides, their precursors (i.e. H-3, Kr-85 and Rn-222 or its precursor, Ra-226) or radionuclides that could, following chemical reactions, become gaseous (i.e. C-14) and fissile radionuclides (i.e. U-233, U-235, Pu-239 and Pu-241, see also Section 4.13). Any such limits should be included in the WPrS and a suitable method of determining the inventory established.

Waste packagers should design a data acquisition system for obtaining the inventories of significant radionuclides in a waste package. A number of strategies are possible, depending on the nature of the waste and inventory and factors such as variability, and include the following:

- definition of an average package inventory, determined from the composition of the overall waste stream and the number of packages expected;
- sampling and analysis of the waste as it is processed, either on a batch basis or for each package, using radionuclide assay methods such as α - or γ -spectrometry or methods specific to particular radionuclides;
- scaling of a pre-defined radionuclide fingerprint using a parameter measured for an individual package, for example mass of waste, dose-rate or the inventory of a particular radionuclide established by spectrometry;
- recording of individual items of waste or consignments of previously defined radionuclide inventory as they are sorted and packed, with appropriate checking.

It is recognised that different strategies may be applied to different radionuclides within the same waste type. This is particularly the case where some radionuclides are readily assayed (for example γ -emitting species) whereas others require considerable effort and may be assigned based on a pre-defined fingerprint (for example β -emitting species).

It should be recognised that inventory recording methods would be developed prior to the processing of waste, probably based on the initial characterisation data or limited sampling. Consequently, appropriate allowance for uncertainties should be included in the development of methods.

The methods used to obtain waste package radionuclide inventories should be appropriate and justifiable. The retention of information relating to these methods and their justification is best ensured through a *methodology statement*. This also provides a means of recording the derivation and justification of limits on particular radionuclides and may be cited in the WPrS.

The methodology statement could be a freestanding document or be part of another document, for example a LoC submission to RWMD. It also could include the strategy for determining the composition of the waste, as discussed in Section 5.9.4.

5.9 Wasteform component inventory

5.9.1 Description of wasteform

A general description of the wasteform is required to provide basic information on its nature and composition. Examples of such a description include 'ferric hydroxide floc immobilised in a cementitious matrix' and 'solid metallic waste encapsulated by cementitious grout'. This description may be recorded in the WPrS.

5.9.2 Proscribed and hazardous materials

A declaration is required that the wasteform is free of *proscribed items* and that any hazardous materials have been rendered safe. Any such declaration should be supported by evidence, and cross-references should be provided in the data records.

A wide range of proscribed materials and items have been defined in the GWPS. Examples include compressed gases, free liquids, pyrophoric materials and aggressive chemicals such as acids. Particular materials also may be proscribed by other relevant regulations, for example transport regulations [i.e. 7, 8].

From the consideration of the relevant regulations (see Section 5.17) a list of ten categories of hazardous materials has been derived:

- combustible materials;
- pyrophoric materials;
- oxidising materials;
- flammable gases and liquids;
- explosives;
- pressurised containers;
- corrosive materials;
- hazardous biological, infectious, pathogenic, carcinogenic, mutagenic and teratogenic materials;
- putrescible materials;
- toxic materials.

Such hazards are additional to those presented by radioactivity. A large number of potentially hazardous materials may be present in wastes, for example heavy metals and toxic inorganic and organic compounds, although many in only trace quantities. The potential effects of hazardous materials are similarly numerous. Consequently, it is not possible to provide a general list of hazardous materials or their possible effects. However, information on hazards is available in the general literature. The requirements imposed by the Hazardous Waste Regulations are discussed in Section 5.17.

The composition of the waste would be considered in the development programme. This provides an opportunity to demonstrate the absence of proscribed items and to document the behaviour and treatment of hazardous materials. This could take the form of reasoned argument, supported by compositional data or information on the nature and source of the waste. In some cases, development work may be required to address a particular hazard, for example a toxic compound present in significant quantities. If necessary, appropriate limits should be placed on the process and conformance data recorded. Any limits on the composition should be included in the WPrS.

Waste packagers should ensure that the evidence to support a declaration is retained. This might be as archived reports on a development programme or arguments presented in a LoC submission.

5.9.3 Inventory of components present in significant quantities

The nature and quantity of the various components of the wasteform will affect both the initial properties of the waste package and their subsequent evolution. Where the

WPS/850/02
March 2008

composition influences product quality, limits may be placed on the quantities of specific components. A compositional inventory is the basis for demonstrating that a waste package conforms to any such limits. Notwithstanding the need to provide such conformance data, a general inventory of wasteform components is also required.

An exhaustive list of significant components cannot be provided. Instead, the significant components should be identified for a given waste type in the development programme. However, the significant components in a wasteform are likely to include the following:

- radioactive material in particulate form;
- encapsulant, capping and conditioning materials;
- metals;
- organic materials;
- inorganic materials;
- irradiated graphite.

Further information on these categories, and their potential influence on product quality, is given below.

The inventory of a particular component should be recorded to an accuracy and level of detail consistent with demonstrating that the effect of the component on the performance of that waste package is understood and acceptable. Waste packagers should establish the necessary accuracy and this would be reflected in the data recording system. The inventory may be provided either through recorded information or as traceable information. The appropriate means for determining the inventory is at the discretion of the waste packager and would depend on whether package-to-package variability is considered significant.

Any limits on an inventory should be embodied in the WPrS. In many cases, limits would be based on the range of compositions used in the development programme, and for which acceptable performance has been demonstrated, rather than a maximum value above which performance is known to be unacceptable.

A strategy for determining the inventories of individual packages should be established, described and justified. This would be influenced by compositional data, the packaging process and the sensitivities established during the development programme. Suggested strategies include the following:

- definition of an average package inventory, determined from the composition of the waste stream and the number of packages;
- definition of a robust envelope that cannot be exceeded by the waste feed, perhaps including arguments based on a comparison of a limit and the capacity of the container; or process controls to limit package component inventories;
- scaling of a compositional fingerprint using a parameter measured for an individual package, for example mass of waste or dose-rate;
- recording of individual items of waste or consignments of identified composition as they are sorted and packed;
- sampling and analysis of the waste as it is processed, most commonly on a batch basis, where a batch is equivalent to a number of packages.

It is recognised that different strategies may be applied to different components within the same waste stream. This is particularly the case where some components are present in

relatively small quantities or otherwise are not expected to influence performance significantly, and which, therefore, would not necessarily be subject to specific limits.

RWMD can provide advice on requirements for the determination of the wastefrom component inventory through the established assessment process.

(a) Radioactive material in particulate form

Particulate material comprises that fraction of the waste that is of relatively small particle size and which is not bound within a solid or collection of solid items of waste and an encapsulating material. Such materials are potentially dispersible, especially under accident conditions, and may represent a specific radiological hazard.

Although it is not possible to provide a precise definition of particulate material, particles that may become airborne or which may be inhaled are of concern. Safety assessments indicate that these categories correspond to particles of less than 100 μ m and less than 40 μ m diameter respectively. However, these particle sizes should not be regarded as the sole definition of material of concern, and waste packagers are encouraged to adopt a cautious definition of particulate material during wastefrom development.

The packaging of wastes should give rise to low and predictable radionuclide release and therefore the immobilisation of radioactive particles is a primary aim. Where such material is expected to be present, the wastefrom commonly would be developed to provide the necessary degree of immobilisation, taking due account of the following factors:

- the nature of particulate material (composition and size range) in the original waste;
- the generation of additional particulate material by degradation, particularly by the corrosion of metals and the spallation of the resulting corrosion products;
- the radionuclide inventory associated with the particulate material.

Where the immobilisation method effectively eliminates the particulate source term, further recording of the quantity of particulates is not necessary. However, where a residual particulate source term is expected, or could develop through ageing effects, the acceptable quantity of particles, and associated radionuclide burden, should be defined.

(b) Encapsulant, capping and conditioning materials

The encapsulant, capping material and any conditioning materials are those materials that are added to the waste to produce a solid and robust wastefrom that fills the volume within the waste container. As such, these materials would comprise a major fraction of the volume of the wastefrom and the relevant quantities should be recorded.

The encapsulant, capping material and any conditioning materials, along with the wastefrom formulation and the process conditions necessary to produce the wastefrom, have been discussed in Sections 5.4, 5.5 and 5.6. It should be recognised that these data classes deal with the definition of the wastefrom and its components, that is the quantities or formulations that have been shown to produce a wastefrom of appropriate properties (the requisite properties are discussed in Section 5.7).

To provide the necessary conformance data, the actual quantities of the encapsulant, capping material and any conditioning materials used in the manufacture of each individual waste package should be recorded. Examples include the quantities of ordinary Portland cement, blast furnace slag and water used to produce a BFS/OPC

WPS/850/02
March 2008

grout, and the quantity of grout delivered to the waste package. Where appropriate, conformance with suitable specifications for materials or materials analyses also should be recorded (for example the use of appropriately specified blast furnace slag and the composition or source of mixing water).

The information to be recorded commonly would be derived from process records, and in many cases, the retention of process records for each package may be sufficient to meet data recording needs.

(c) Metals

The metals content of a packaged waste is the quantity of un-combined elemental or alloyed metals in the waste. In addition, metals may be used as part of the process, for example in the form of sacrificial drums used for wastes that are to be super compacted (these also could be recorded as inactive feed materials). Manufactured items that are substantially metallic should be recorded as metals. In summary, it may be necessary to record some or all of the following:

- composition of the metals (relatively common and corrodable metals such as iron or steel, aluminium, magnesium alloys and uranium are of particular significance);
- mass or mass fraction of individual metals in a package;
- nature of the metals or metallic items or manufactured items that are predominantly metal (typical size or size range, estimated surface area, complexity);
- condition of the metals (corrosion of surfaces, surface coatings, and attached items).

It is normally not necessary to assess small amounts of attached corrosion product or to record this separately from the quantity of metals. However, the separate recording of extensively or completely corroded metals as inorganic materials is required.

The presence of metals may affect the properties of the wastefrom and, in particular, may influence the evolution of the wastefrom after manufacture and under disposal conditions. Of particular concern is corrosion and any resulting expansion and, in some cases, the generation of gas. Appropriate corrosion rates may be determined in a development programme and, if appropriate, should be recorded as traceable information.

In addition, some metals, although not present in quantities sufficient to influence waste package performance, may have a more general significance. Examples might include highly toxic metals and neutron reflectors such as beryllium. Any requirement to record such metals should emerge from interactions with RWMD.

(d) Organic materials

A wide range of organic compounds and materials may be present in packaged wastes. It is not possible to provide an exhaustive list of such materials, but typical sources of organic materials may include items of waste manufactured from materials such as plastic, rubber or paper, complexants and decontaminants, some oils and lubricants, paints, waste cans and wrappings, organic ion exchange resins and any polymeric materials used for waste immobilisation. In cases where relatively rapid degradation of the organic material is expected, an estimate of the extent of degradation and the nature and quantities of the degradation products also may be required.

The effects of organic materials are numerous and depend on the nature of the materials and the period of waste management. Organic materials may directly influence product quality, for example during solid waste infilling. Organic materials may also influence the evolution of the wasteform and, in the longer term, have a detrimental effect on the performance of a GDF. Issues that may be significant include:

- materials that directly influence product quality, for example by affecting the setting of cements or dimensional changes after processing (for example re-assertion of compacted wastes);
- materials or their degradation products that influence the evolution of the waste package, for example through the formation of acidic degradation products that may accelerate corrosion or the formation of gases by microbial or chemical degradation;
- materials that may act as neutron moderators or reflectors, affecting the nuclear reactivity of the packaged waste;
- materials that may preferentially absorb radionuclides from solution under disposal conditions (organic ion exchange resins);
- materials or their degradation products that may reduce the alkaline buffering capacity of a cement-based GDF through the production of acidic species;
- materials that may be degraded to produce complexants that adversely affect the solution concentration of important radionuclides;
- materials that may be degraded to produce non-aqueous phase liquids that adversely affect the containment of radionuclides.

The organic materials content of a waste package also should be characterised as a contribution to the general description of the waste package.

The magnitude of the effect of organic materials on the performance of the disposal system as a whole may depend on a total inventory rather than on individual package contents. If this is the case, RWMD may advise on appropriate limits during the assessment of packaging proposals.

(e) Inorganic materials

The inorganic materials content of a waste product encompasses the inorganic constituents of the waste. It excludes materials included in the other categories discussed in this section (un-combined metals, organic materials and irradiated graphite). Examples are ceramic materials, glass, general and trace chemicals, hydroxide or other precipitates in slurry wastes and dissolved species. The encapsulating material and other added components of the wasteform are to be recorded separately and are discussed above.

This category encompasses a wide range of different materials and it is not possible to provide an exhaustive discussion of potentially significant materials or their effects on performance. However, examples include:

- reactive chemicals and materials that degrade under the alkaline conditions expected in the disposal system;
- dissolved or soluble species that affect the setting of cements;
- materials that may affect nuclear reactivity and therefore influence criticality safety;

WPS/850/02
March 2008

- materials that may preferentially absorb radionuclides from solution under disposal conditions (inorganic ion exchange materials);
- materials with relatively low ignition or melting temperatures;
- metastable or amorphous materials that may change state or shape after packaging.

Corrosion products may be described as inorganic materials, and should be recorded if the quantities in the original waste are significant.

Waste packagers are advised that it is not necessary to record estimates of the quantities of inorganic materials that might be produced by degradation of waste after packaging, although enabling data to allow such estimates to be produced if required would be recorded (for example heat output, storage conditions and timescales). However, such degradation should be taken into account in establishing limits on the constituents of the waste.

(f) Irradiated graphite

Irradiated graphite is defined as that material used as a moderator and/or reflector in reactor cores or fuel elements and that has been exposed to neutron irradiation. The quantity and irradiation history of these materials are required to be recorded separately as they will have accumulated Wigner energy that may potentially be released at some time after the waste is packaged, thereby threatening package integrity and the performance of a GDF.

Where irradiated graphite is to be packaged, the quantity per package may be limited by consideration of the Wigner energy content, based on an understanding of the irradiation history and taking account of generic studies. Alternatively, the graphite may be tested or modelled to show that it contains an insignificant quantity of stored energy or that any release would not have significant consequences. RWMD have produced guidance on the issues to be addressed during the packaging of irradiated graphite [9] and can provide advice and guidance on specific packaging proposals. Where a limit on the quantity or stored energy content of graphite is judged necessary, this should be included in the WPrS.

5.9.4 Methodology statement

The methods used to obtain waste package data must be appropriate and justifiable. To provide for the retention of information relating to the relevant data acquisition system, it is suggested that the system should be described in a methodology statement. The methodology could take the form of a freestanding document or be part of a wider document, for example a LoC submission to RWMD.

The primary purpose of the methodology statement is to document the strategies as discussed in Section 5.9.3. This may include cross-references to the relevant process records where basic enabling data are reported. It is of particular importance to record the justification for the proposed strategy, referring to appropriate sources of information, for example the development programme and the primary characterisation of the waste.

Waste packagers are advised that the methodology statement also provides a suitable means of recording the derivation and justification of limits on package contents (recognising that the numerical limits would also be reported in the WPrS) and arguments demonstrating the absence of proscribed items or hazardous materials. The methodology statement would then provide a reference to be cited in the WPrS.

5.10 Waste package properties

The 'Waste Package Properties' are those properties of an individual package that may be measured and recorded at the time of packaging, commonly to demonstrate conformance with explicit limits. This information may be distinguished from the general requirement to record product quality information used in the development of the WPrS and discussed in Section 5.7 (Nature of the Waste Package).

5.10.1 Waste package classification

Various classifications may be applied to packaged wastes under the Transport Regulations. These may include ILW, LLW, Low Specific Activity (LSA) material, Surface Contaminated Objects (SCO) and those packages that may be transported as 'non-fissile' under the IAEA Transport Regulations [10]. These classifications are not considered in detail herein.

Where a package is to be classified in a particular manner, this should be recorded. It would be necessary to record the evidence that supports the classification, for example the measured or estimated specific activity of the packaged waste.

5.10.2 Gross mass

The gross mass of a waste package may be defined as the total mass of the package, in tonnes or kilograms, when consigned for disposal. A record of gross mass is required to satisfy transport regulations.

The gross mass of a waste package is to be provided in the recorded information. Maximum gross waste package masses are provided in the waste package specifications (*WPS/300 Series*).

For process control and to confirm conformance with other requirements of the WPrS, the masses of individual components of the waste package may need to be defined. Alternatively, information could be recorded that would enable the mass of such items to be deduced. The accuracy of the recorded mass will depend on the approach taken. For example, cumulative systematic errors associated with summing of component masses or the error associated with weighing the package.

5.10.3 Surface dose rate

The surface dose rate, or the dose rate at a defined distance from the package, may be limited by the requirements of processing, storage or handling. For those packages that are also transport packages, dose rates are limited by the IAEA Transport Regulations [10]. Consequently, appropriate dose rates should be measured and recorded for each package.

Where specific dose rate limits are imposed by the use of a particular process or storage facility, the limits should be recorded in the WPrS. It also may be necessary to provide a reference to the applicable limits and the relevant issues of regulations to protect against subsequent changes in regulation. Data records should be sufficient to demonstrate conformance with any such limits.

5.10.4 Non-fixed surface contamination levels

The non-fixed surface contamination, both for beta, gamma and low toxicity alpha emitters, and for other alpha emitters, may be limited by a requirement to demonstrate safety during processing, storage or handling at a disposal facility. For those packages that are also transport packages, surface contamination levels are also limited by the IAEA Transport Regulations. Consequently, appropriate contamination levels, expressed in Becquerels (Bq) per unit area, should be determined and recorded for each package.

Where specific surface contamination limits are imposed by the use of a particular process or storage facility, the limits should be recorded in the WPrS. It may be necessary to provide a reference to the applicable limits and the relevant issues of regulations to protect against subsequent changes in regulation. Data records should be sufficient to demonstrate conformance with any such limits.

Although contamination is most likely to occur during waste packaging, waste packagers should be aware of the possibility of contamination during storage and handling and as a consequence of waste package ageing. Consequently, it would also be necessary to provide evidence of the level of contamination at the time a package is consigned for disposal.

5.10.5 Heat output

The heat emitted by a waste package should be an estimate of the rate of generation of heat (expressed in Watts per waste package), taking account of all relevant and significant processes. The heat-generating processes might include radioactive decay, chemical degradation processes such as corrosion and microbial degradation of organic materials. The heat output will be time-dependent and, in general, the peak value together with values at 2040 (the assumed earliest time for transport) and 2090 (the assumed earliest time for disposal vault backfilling) will be of interest.

The heat output will influence the evolution of the waste package under storage and disposal conditions. In addition, the overall heat loading for a GDF may be a significant parameter in determining the performance of a GDF and an accurate estimate of the heat loading would be required to demonstrate conformance with safety cases. Consequently, data for individual packages should be provided to assess the need for an emplacement strategy within a GDF.

The potential heat generating processes should be reviewed during the development programme. Indicative estimates of the heat output, based on the estimated average and maximum radionuclide and compositional inventories of the waste, should be produced and reviewed as part of the consideration of LoC submissions.

Limits on the total heat output of standard waste packages have been specified in the appropriate waste package specification (i.e. *WPS/300 Series*). In addition, limits specific to the particular type of waste may be identified in the development programme. If this is the case, these limits should be embodied in the WPrS.

Data records should include an estimate of the heat output to demonstrate conformance with the limits or the quantities of wastefrom components. As measurement of the heat output is unlikely to be feasible, estimates should be provided, typically based upon the radionuclide and compositional inventories.

5.11 Waste Product Specification

Individual data records should provide a cross-reference to the appropriate WPrS, which is expected to be a freestanding document that has been reviewed and accepted by RWMD. Waste packagers are advised that the WPrS is an important document and appropriate steps should be taken to ensure the retention of the document throughout the lifetime of a waste package. When a process is substantially modified, the WPrS should be revised to reflect the justified change in the process, either by issue of a new version or by complete overhaul, and reissued

The principal purpose of the WPrS is to provide a definition of the product that a waste packaging process is intended to produce. This would include a general description of the waste package, all necessary specifications of the components of the waste package and any limits on its contents. In addition, the WPrS should provide cross-referencing to enabling data, such as the results of a development programme, to justify the various specified or limiting values. The required contents of a WPrS are to be a freestanding document that has been reviewed and accepted by RWMD. Waste packagers are advised that the WPrS is an important document and appropriate described in more detail in *Guidance on the Structure and Format of Waste Product Specifications, WPS/620*.

In practice, the WPrS should define the range of acceptable waste package compositions and processing conditions for which satisfactory waste package performance has been demonstrated (in association with a development programme). Conformance of individual packages to the specifications established in this way provides a high level of confidence that the waste package properties will be acceptable for future handling, transport and storage.

The data records should include a declaration of conformance or non-conformance with the WPrS, together with evidence to support this declaration. Evidence is provided by a comparison of the individual package data with any limits recorded in the WPrS. The data records should include documentation to confirm that such a comparison has been performed.

Details of any non-conformance with the WPrS should be recorded and remedial actions stated and confirmed. Waste packagers should note that demonstrated conformance with the WPrS, or appropriate remedial action, is likely to be a necessary precursor to the acceptance of waste for long-term storage or disposal within a GDF.

5.12 Waste package history

The record of the waste package history should provide a description of the conditions to which the package has been subjected after its manufacture. The significant aspects of the package history may include some or all of the following:

- date of production;
- identity of the waste packaging plant(s);
- identity and location of the waste package store(s);
- dates on which the waste package was placed in and removed from store(s)
- movement or retrieval for inspection;
- the results of any NDT analysis;
- storage environmental conditions;
- checks on the condition of the waste package in store;

WPS/850/02
March 2008

- any abnormal occurrences or incidents involving the waste package;
- remedial action taken in respect of a waste package that becomes non-conforming.

The package history will provide important enabling data to define the condition of the waste package and for any subsequent consideration of the evolution of the package and its properties. In addition, the development programme may have identified particular requirements to be placed upon the storage conditions to ensure the longevity of the package. Any such limits should be included in the WPrS. The package history will provide a demonstration of conformance with such limits.

The necessary storage conditions should be considered in the development programme. This should reflect the potentially differing sensitivity of different package designs to storage conditions - see *Guidance on Environmental Conditions during the Storage of Waste Packages, WPS/630*. The influencing factors may include:

- temperature and humidity;
- rate of air flow or number of atmosphere changes;
- rate of deposition of potentially corrosive or reactive chemicals from the atmosphere, for example salt or sulphates;
- method of stacking packages, including the use of spacers or pallets;
- use of overpacks or other protection (for example sheeting), and their specification.

The environmental conditions in a store may be actively controlled through ventilation, atmospheric drying or heating. Where this is the case, the intended conditions may be recorded together with checks to ensure correct operation. In cases where such control is not available, conditions are likely to fluctuate. Where this is the case, the expected range of conditions should be assessed and the conditions experienced recorded.

Periodic checks on the condition of packages would be necessary and the results of such checks should be recorded, either in the recorded information or by reference to the appropriate storage records.

The waste package history data class will evolve with the package and may only be completed, therefore, at the time of consignment of the package for disposal. Waste packagers should ensure that adequate provision is made for the retention of the necessary information up to that time.

5.13 Criticality safety

Individual data records should provide a cross-reference to the appropriate CCAD, which is expected to be a freestanding document that has been reviewed and accepted by RWMD. Waste packagers are advised that the CCAD is an important document and appropriate steps should be taken to ensure the retention of the document throughout the lifetime of a waste package.

Where necessary, the CCAD should be revised to reflect any development or optimisation of the packaging process.

The CCAD should establish the safe working limit for the fissile material content of the waste package and define how conformance with that limit would be demonstrated in practice. This may be through direct measurements of fissile material contents, indirect

measurements based on other radionuclides or inactive components or through reasoned argument. It should be noted that limits may be placed on inactive materials where these may influence nuclear reactivity (examples might be moderators and reflectors such as graphite, beryllium and polythene). A requirement to obtain such information has also been defined under data classes 8 and 9 (Sections 5.8 and 5.9). The need to demonstrate conformance with fissile material limits would be an important criterion in establishing the significance of relevant information.

The fissile material limits should be based either on a CSA specific to the waste package, which takes account of all stages of waste management, or on screening levels produced for a generic packaged waste type. Cross-references to these assessments should be explicit and provided either in the data records or in the CCAD. Further guidance on the production of CCAD is available in *Guidance on the Preparation of Criticality Compliance Assurance Documentation for Waste Packaging Proposals*, WPS/625.

The data records should include a declaration of conformance or non-conformance with the safe fissile limit established in the CCAD, together with evidence to support this declaration. Such evidence is provided by a comparison of the individual package data with any explicit limits or other indirect criteria recorded in the CCAD. The data records should include documentation to confirm that such a comparison has been performed.

Details of any non-conformance with the safe fissile limit or other criteria established in the CCAD should be recorded. Any necessary remedial actions should be stated and confirmed.

Waste packagers should note that demonstrated conformance with fissile material limits, as indicated by the CCAD, or appropriate remedial action, is likely to be a necessary precursor to the acceptance of waste for long-term storage or disposal.

5.14 Administrative

The necessary administrative information will depend on the requirements imposed by regulators and by RWMD or their successor. The required information may comprise the identity of a contact within the waste packager organisation, which would be responsible for the packaged waste, and a record of the authorisation and agreement for transfer of waste package for disposal. Clearly, the data class would be completed only at the time of transport of the package to a disposal facility.

5.15 Transport

This record should provide a cross-reference to the consignment documentation covering the transport of the waste packages and include any documentation needed to meet Department for Transport (DfT) requirements. A detailed description of the necessary documentation is provided elsewhere and may be subject to revision [11, 12]. Clearly, this data class would be completed only at the time of transport, and the necessary documentation may be held separately from the *data record* as traceable information.

5.16 Nuclear Material Accountancy and Safeguards

International safeguards have been established under the Euratom Treaty to ensure that the whereabouts of all declared nuclear materials arising from civil nuclear activities are monitored and recorded [13]. The term 'nuclear materials' encompasses:

WPS/850/02
March 2008

- ore - materials from which 'source materials' may be obtained by chemical and physical processing;
- source materials – natural uranium, depleted uranium, thorium,
- special fissile materials – Pu-239, uranium enriched in U-235 or U-233, any material containing one or more of these isotopes.

Materials produced or used for military purposes are currently excluded from safeguards measures in the UK; however, all 'civil' nuclear material in the UK is subject to Euratom safeguards under the Euratom Treaty. A small number of civil UK facilities are also subject to direct oversight by the IAEA. Where waste is subject to safeguards, waste packagers are required to ensure that the recorded information is consistent with meeting the treaty requirements.

In practice, a Physical Inventory Listing (PIL) should be provided, containing the information required to fulfil safeguards requirements. The following information should be provided (noting that several items potentially duplicate or draw upon information required elsewhere in the package data records):

- statement as to whether the waste package is subject to safeguards, is non-safeguarded (of military origin) or exempt (containing no fissile material);
- measurement basis (the means of determining the measured, estimated or calculated quantities of fissile materials);
- batch designation;
- number of items;
- material description;
- weight of elements;
- uranium category;
- weight of fissile isotopes;
- obligation code;
- intended use of the material (in the case of waste this may be 'measured discard' or 'retained waste');
- date and time of movement, and identity of issuing and receiving material balance area (where appropriate).

The methods for determining the quantities of materials that fall under safeguards will be the same as for the radionuclide inventory and other significant components of the waste package; see Sections 5.8 and 5.9.3. Waste packagers should consult their local Nuclear Materials Accountancy and Safeguards office for advice to ensure they comply with the appropriate regulations.

5.17 Hazardous wastes

In the UK, wastes containing particular hazardous materials are controlled by the Hazardous Waste Regulations [14]. These regulations, which implement the European Commission Hazardous Waste Directive (HWD) [15], provide a definition of '*special waste*' and the requirements for their control. Further guidance on special waste is available [16,17]. Together, these documents provide an overview of the special waste legislative framework and the Environment Agency (EA) and Scottish Environment Protection Agency's (SEPA) recommended methodology for assessing whether a waste is special. The EA/SEPA guidance document also provides information on how the

Chemicals Hazard Information and Packaging for Supply (CHIP) regulations [18] can be used as a further means of assessing risks and categories of danger of potentially hazardous materials.

The determination of waste package components that comprise special wastes will be the same as for other significant components of the waste package; see Sections 5.9.2 and 5.9.3. Where the waste includes materials that are classified as special wastes, the recorded information should contain a cross-reference to the necessary consignment documentation. Hazardous wastes and the necessary documentation are defined in Reference [14]. It is expected that such documentation need to be completed only at the time of transport to a disposal facility.

APPENDIX A SUMMARY OF GUIDANCE

Data Class	Category of Information	Definition	Comments
1. Waste Package Identifier	Package specific data	Unique identifying code for each package	Provide linkage to full data record
2. Waste	Generic information	Brief description of the waste, its origins and storage	Basic description to allow discussion, not full composition. Origin and storage facilities provide enabling data as a basis for extrapolating recorded data
3. Waste Container	Package specific data Batch specific data Generic information	Container specification, documentation and inspection records	Mixture of information. Specifications etc may be traceable, generic information cited in WPrS. Some records may be batch or package specific data for individual containers
4. Encapsulant, Capping and Conditioning Material	Generic information	Descriptions and specifications of the materials used to produce the wasteform	May be recorded in WPrS
5. Wasteform Formulation	Generic information	Quantities of constituents used to produce the wasteform	Includes both the target formulation and the permitted envelope. Should include references to development programme
6. Process Conditions	Package specific data Generic information	Description of required process conditions and necessary conformance data/records	Specification of process is generic information. Conformance data will be package specific

Data Class	Category of Information	Definition	Comments
7. Nature of the Waste Package	Generic information	Description of the expected physical and chemical properties of a waste package when produced in conformance to the WPrS	Data obtained during development programme. Describes the expected properties of active packages, as these would not be directly measured
8. Waste Package Radionuclide Inventory	Package specific data Generic information	Inventory of significant radionuclides and the methodology used to obtain it	Definition of significant radionuclides will be case specific and needs to be recorded. Method for obtaining the inventory should be traceable
9. Wasteform Component Inventory	Package specific data Generic information	Inventories of significant constituents of a waste package and the methodology used to obtain them	Definition of significant constituents will be case specific and needs to be recorded. Methods for obtaining the inventories should be traceable
10. Waste Package Properties	Package specific data	Measured values of defined properties required to show conformance to the WPrS	Limits may be placed on some properties (probably through WPrS). These data would be used to show conformance with these limits
11. WPrS	Generic information	Cross-reference to the relevant WPrS	WPrS should describe target waste package and record the limits that have to be met to ensure product quality
12. Waste Package History	Package specific data	History of the package after manufacture	Provides enabling data to estimate how the package has evolved.
13. Criticality Safety	Package specific data Generic information	Cross-reference to the relevant CCAD and necessary compliance data	Could include cross-reference to relevant package inventory data

Data Class	Category of Information	Definition	Comments
14. Administrative	Administrative information	Cross-reference to or retained general administrative records	To be defined as necessary
15. Transport	Administrative information	Cross-reference to relevant consignment records and approvals	To be defined as necessary
16. NMA and Safeguards	Package specific data	Recording of information required to demonstrate compliance with Safeguards requirements	Could include cross-reference to relevant package radionuclide inventory data
17. Hazardous Wastes	Package specific data	Recording of information required to demonstrate compliance with Hazardous Waste Regulations	Could include cross-reference to relevant component inventory

GLOSSARY

- administrative information* That part of the *data record* that is not directly related to the processing of the waste, for example QA documentation, consignment records and identifiers. May be treated either as *recorded information* or as *traceable information*.
- batch specific data* Information common to several packages that constitute a subset of the packages of a particular *waste type*, for example purchase records for containers or raw materials and assay data for a batch of waste. Commonly treated as *traceable information*.
- British Radwaste Information Management System (BRIMS)*
- A data recording system developed by the UK nuclear industry and its regulators to provide a common tool for the recording of a wide range of radioactive waste-related information. For further information on BRIMS, see Reference [5].
- Criticality Control Assurance Documentation (CCAD)*
- Documentation that describes and justifies the means of ensuring that a package would satisfy criticality safety requirements, including a *methodology statement* for determining fissile material content and *limits* on that content. A part of the *generic information* commonly treated as *traceable information*.
- conformance data* Those parts of the *data record* recorded to demonstrate conformance with limits. The alternative term compliance also may be used. Commonly treated as *recorded information*.
- data acquisition system* The methods used to obtain (numerical) information required in the *data records* for a particular *waste type*. May include both assay or measurement methods and the provision of information through a *development programme*.
- data class* One of the 17 constituent components of a complete data record as defined in the *Waste Package Data and Information Recording Specification, WPS/400*.
- data record* The complete collection of information relating to a waste package required to enable assessment against the requirements for safe and cost-effective handling, transport, storage and potential disposal. Sub-divided into 17 *data classes*.
- data recording system* The tailored system for completing the *data record*. To include appropriate components of the development programme, the *data acquisition system(s)* and process records, the completion of the recorded information and the acquisition and retention of other traceable information.

<i>development programme</i>	The programme of research and development undertaken to characterise the waste and define and justify the necessary processing and packaging methods. Some results will be part of the <i>generic information</i> and are commonly treated as <i>traceable information</i> .
<i>enabling data</i>	That information relating to the properties of a waste package, its contents or environment, that might be required to allow the prediction of some (currently undefined) aspect of the performance of the package or to allow initial data set to be expanded using suitable extrapolation methods. Potentially a sub-set of the information contained in the <i>data record</i> .
<i>generic information</i>	That part of the <i>data record</i> that defines and justifies the process used to produce a package, including <i>manufacturing specifications</i> . This information would be common to all packages from a given <i>waste type</i> . Commonly treated as <i>traceable information</i> .
<i>guidance quantity</i>	The guidance quantity is a value expressed in Becquerels used to determine whether a radionuclide concentration is significant with regard to transport and deep geological disposal activities.
<i>hazardous materials</i>	Materials present in waste that may present a non-radiological hazard under defined circumstances.
<i>(specified) limit</i>	A limit placed on a particular property of a waste package or its contents to ensure adequate performance, commonly based on the results of a <i>development programme</i> .
<i>manufacturing specification</i>	A specification for the manufacture of a container or associated furniture, usually considered a part of the <i>generic information</i> . An example of <i>traceable information</i> that commonly pertains to several <i>waste types</i> .
<i>methodology statement</i>	A document, report or statement in a higher-level document that defines and justifies the method for acquiring particular information, for example package radionuclide inventories. Potentially a description of the operation of a <i>data acquisition system</i> . Commonly treated as <i>traceable information</i> .
<i>package database</i>	A (commonly software-based) system for retaining <i>recorded information</i> . The information held would normally exclude traceable information and therefore would not be identical to a complete <i>data record</i> .
<i>process records</i>	Information acquired during the processing of waste, for example dispensed masses of waste and encapsulating materials, processing conditions and radiological data such as dose rates. May be included directly in the <i>recorded information</i> or used to infer <i>package specific data</i> .

<i>package specific data</i>	Information that applies to a specific individual package. Commonly including process records, measured or inferred waste and wasteform compositions and any other <i>conformance data</i> .
<i>product quality</i>	The properties of a waste package and its expected performance under foreseeable circumstances. Usually required to meet the standards and specifications defined in the GWPS.
<i>proscribed items</i>	Items or materials identified by RWMD as subject to exclusion from waste packages as they may threaten the performance of the package, for example gas cylinders and free liquids. Includes some <i>hazardous materials</i> .
<i>recorded information</i>	The means of retaining those parts of a <i>data record</i> that comprise the information directly associated with a package or its contents. May include <i>package specific data</i> and some <i>administrative information</i> .
<i>significant (constituent)</i>	Those constituents of a waste package (radionuclides, chemical species, materials, items of waste etc) that potentially influence some aspect of <i>product quality</i> or which form part of enabling data. Those items for which a <i>limit</i> may be required, to be identified in the <i>development programme</i> .
<i>special waste</i>	In general terms, special wastes are those that are dangerous or difficult to handle because they include hazardous or toxic materials.
<i>traceable information</i>	The means of recording and retaining the components of a <i>data record</i> that comprise separate documents, reports and drawings that are cited in the <i>data record</i> (or in other documents) but held separately. Particular items of traceable information may pertain to several <i>waste types</i> .
<i>Transport Regulations</i>	Generic term to cover both UK Statutory Instruments for road and rail transport of radioactive materials and the IAEA Transport Regulations [8].
<i>Waste Product Specification (WPrS)</i>	A document that defines the product of a packaging process, including quantities, feed materials and process parameters. Summarises limits placed on significant items to provide a basis against which conformance data may be judged. A part of the <i>generic information</i> commonly treated as <i>traceable information</i> .
<i>waste type</i>	Waste identified by a waste packager for which a single processing and packaging method has been developed and for which a data acquisition system has been tailored. Commonly, but not necessarily, equivalent to a waste stream as defined in the UK Radioactive Waste Inventory.

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