

## Geological Disposal

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# WPS/921 Guidance on the preparation of submissions for the disposability assessment of waste packages by use of a Standard Waste Package Description

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October 2010



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## Executive Summary

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

The WPSGD provide specifications for waste packages 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 Licence Companies (SLCs) in the early development of plans and strategies for the management of radioactive wastes.

RWMD have developed a process by which the disposability of proposed waste packages can be assessed by way of a demonstration of their compliance with a *Standard Waste Package Description* (SWPD). This document provides guidance to assist SLCs in the preparation and submission of proposals to package waste in such a manner that the waste packages that resulted from the implementation of those proposals could be shown to be compliant with a SWPD.

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.

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## **List of Contents**

<b>Executive Summary</b>	<b>iii</b>
<b>1 Introduction</b>	<b>1</b>
<b>2 Background</b>	<b>1</b>
2.1 The concept of geological disposal	1
2.2 The assessment of packaging proposals	3
2.3 Standard Waste Package Descriptions	5
<b>3 Form and contents of a submission</b>	<b>7</b>
3.1 Identification of the SWPD and confirmation of basic compliance	7
3.2 The 'Nature and Quantities' report	9
3.3 Waste Product Specification	10
3.4 Criticality Compliance Assurance Documentation	10
3.5 Description of interim storage arrangements	10
3.6 Arrangements for quality management	11
3.7 Arrangements for data and information recording and storage	11
<b>References</b>	<b>12</b>
<b>Appendix A Typical form of SWPD</b>	<b>13</b>
<b>Appendix B Submission contents checklist</b>	<b>15</b>
<b>Appendix C Glossary of terms used in this note</b>	<b>17</b>

## **Abbreviation and acronyms used in this document**

ALARP	as low as reasonably practicable
BPEO	best practicable environmental option
BPM	best practicable means
CCAD	Criticality Compliance Assurance Documentation
DSS	Disposal System Specification
DSFS	Disposal System Functional Specification
DSTS	Disposal System Technical Specification
DSSC	Disposal System Safety Case
GDF	geological disposal facility
GWPS	Generic Waste Package Specification
HLW	high level waste
ILW	intermediate level waste
IWS	integrated waste strategy
LLW	low level waste
LoC	Letter of Compliance
MRWS	Managing Radioactive Waste Safely
NDA	Nuclear Decommissioning Authority
RWMD	Radioactive Waste Management Directorate
SLC	Site Licence Company
SWPD	Standard Waste Package Description
UKRWI	United Kingdom Radioactive Waste Inventory
WPrS	Waste Product Specification
WPSGD	Waste Package Specification and Guidance Documentation



## 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) process [1] to plan the development of a Geological Disposal Facility (GDF).

RWMD, acting as implementer and future operator of a GDF, and therefore as the ultimate receiver of wastes for disposal, has established standards and performance specifications for packaged waste to enable the industry to condition radioactive wastes in a form that will be compatible with future transport to and disposal in a GDF. These are published in the form of generic specifications for waste packages containing the different categories of higher activity waste.

To assist Site Licence Companies (SLCs), and others with an interest in the packaging of higher activity waste for disposal, we also produce packaging specifications and guidance under the banner of the *Waste Package Specification and Guidance Documentation* (WPSGD). The prime purpose of the WPSGD are to present our generic packaging standards and specifications at the user level and to provide explanatory material and guidance that users will find helpful when it comes to application of the generic specifications to practical packaging projects. For further information on the extent and the role of the WPSGD, reference should be made to [2]<sup>1</sup>.

We have established a process by which plans to package waste can be assessed as to their ability to result in waste packages which are compliant with our packaging specifications and thereby disposable in a GDF [3]. If this can be shown to be the case we signify the 'disposability' of the proposed waste packages by the issue of a *Letter of Compliance* (LoC).

We have now developed an alternative process by which the disposability of waste packages can be assessed. This process, which is founded on a demonstration of the compliance of waste packages with a *Standard Waste Package Description* (SWPD), offers waste packagers an accelerated route to LoC endorsement where an existing Final stage LoC and disposability case for sufficiently similar waste packages is available.

The purpose of this guidance is to assist waste packagers in the preparation and submission of proposals to package waste in a manner that will permit RWMD to assess the disposability of the proposed packages against a SWPD. It is a counterpart to WPS/908 [4] which provides guidance on the preparation and submission of proposals to package waste that will require assessment by way of the 'full' disposability assessment process. For packaging proposals which are not adequately bound by a SWPD, this latter approach to obtaining LoC endorsement must be followed.

## 2 Background

### 2.1 The concept of geological disposal

A key aspect in the production of standards and specifications for packaged radioactive waste is the definition of a disposal system which encompasses all stages of the long-term

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<sup>1</sup> The full suite of the WPSGD can be accessed at <http://www.nda.gov.uk/aboutus/geological-disposal/rwmd-work/assessments/waste-specifications.cfm>.

management of waste packages from their manufacture through to final disposal. In the case of higher activity wastes<sup>2</sup>, the UK government has decided that the latter stage should be by way of geological disposal.

In line with the MRWS process, we are continuing to develop concepts for the geological disposal of higher activity wastes and, whilst the exact nature of a GDF for the disposal of such wastes is not currently defined, it is envisaged that their long-term management would comprise a number of distinct stages including:

- the retrieval of the raw waste and the manufacture of passively safe and disposable waste packages;
- a period of interim surface storage, usually at the site of waste arising or packaging;
- transport of the waste packages to a GDF;
- transfer of waste packages underground followed by a period of monitored storage underground, during which retrieval<sup>3</sup> by relatively simple means would be feasible; and
- eventual sealing and closure of the GDF.

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<sup>4</sup>.

As part of our programme for the implementation of geological disposal in the UK we have developed a suite of documents known as the Disposal System Safety Case (DSSC) [5]. The purpose of the DSSC is to present methods, evidence and arguments concerning the safety of the geological disposal of higher activity waste in the UK. This includes assessments of the safety of the transport of waste to a GDF, and the construction, operation and long-term safety of such a facility, along with the current status of supporting research in key areas such as waste package longevity, criticality safety.

An important component of the DSSC is the Disposal System Specification (DSS), which sets out a definition of the requirements of a geological disposal system. The DSS comprises two documents:

- The Disposal System Functional Specification (DSFS), the purpose of which is to identify and document the overall goals, objectives and constraints of a disposal system; and
- The Disposal System Technical Specification (DSTS) which underpins and develops the high-level DSFS by describing in more detail the requirements and constraints on the disposal system, together with a justification for each requirement.

The safety philosophy adopted by most concepts for the geological disposal of radioactive waste investigated and implemented worldwide [6] is one of containment of radionuclides

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<sup>2</sup> Higher activity waste includes vitrified high level waste (HLW), intermediate level waste (ILW) and certain categories of low level waste (LLW) not suitable for disposal in existing near surface facilities. Other radioactive materials (e.g. uranium, plutonium and spent nuclear fuel) would also be included in this broad description if they were declared as waste in the future.

<sup>3</sup> The MRWS White Paper states that the matter of keeping a GDF open for an extended period of time, to facilitate the retrieval of waste packages, would be decided at a later date and in consultation with regulators and the host community.

<sup>4</sup> It should be noted that, in view of the wide range of wastes that could be the subject of geological disposal, a single GDF may adopt different disposal concept for different types of waste.

by multiple barriers, of which that provided by the waste package is a key component. In some cases the barrier provided by the waste package can be considered as two independent but complementary barriers, the waste container and the wasteform, each of which can play an important role in the containment of radionuclides.

As the MRWS 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. A detailed disposal system design and associated safety cases will be developed to suit the specific characteristics of the site and packaging standards will be updated to reflect the new circumstances as appropriate. It is not however believed that such updating would result in the packaging criteria becoming more onerous.

## **2.2 The assessment of packaging proposals**

Since the mid-1980s the UK SLCs 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 proposals to produce disposable waste packages, a responsibility assumed by RWMD in 2007 following Nirex's incorporation into NDA.

The assessment of the disposability of waste packages was originally carried out by way of the 'Letter of Comfort' process which, following two decades of use and development, has evolved into the current disposability assessment process [3] with endorsement being indicated by the issue of a 'Letter of Compliance'. This evolution included the establishment of a more structured assessment process with detailed advice being issued to the waste packager highlighting further information needs, or need for further development and/or research before endorsement of the proposed waste packages could be made. 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 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 [7].

In undertaking disposability assessments we determine whether waste packages, when manufactured in accordance with a proposed process, will have characteristics compliant with plans for transport to, and operations at a GDF, and ultimately whether they could be accommodated within the developing safety cases for a GDF. In this way we ensure that the barrier provided by the waste package, one of the multiple barriers that make up the geological disposal system, will perform in an adequate manner.

The relevant generic specification (e.g. the GWPS [8] in the case of waste packages containing ILW) plays a key role in the assessment as it defines the properties that waste packages have to possess in order to satisfy these requirements.

The main output of a disposability assessment is an *Assessment Report* which may be accompanied by the issue of a LoC confirming our belief that the waste packages which would result from implementation of the packaging proposal would be disposable in a GDF. The case for the disposability of the proposed waste packages which is included in the Assessment Report, can be used by an SLC as an important component of a Radioactive Waste Management Case which has to be produced to support a waste retrieval and conditioning project [9].

The disposability assessment process is applied throughout all the phases in the development of a waste packaging facility, starting when the waste packager is identifying packaging concepts, through design and construction phases, to final commissioning and active operations.

The process is normally divided into three stages which are aimed to correspond with the three key stages of development of a packaging facility<sup>5</sup> and their associated safety cases, namely:

- **Conceptual stage;** during which the compatibility of the proposed waste treatment and packaging process with anticipated long-term waste management requirements is assessed.
- **Interim stage;** during which more detailed inventory data and final design specifications, including results from research and development is assessed in order to confirm that the intended waste packages will be compliant with the standards and specifications defined within the relevant generic specification.
- **Final stage;** by which stage all of the research and development related to the waste package should be complete and all the information needed to support the disposability assessment available. If the waste packages, as proposed to be manufactured in the as-built plant, can be shown to be compliant with the relevant generic specification and the needs for transport to and disposal in a GDF, this will be signified by the issue of the Final stage LoC.

Each stage of a disposability assessment has two distinct objectives;

- i) Technical evaluations - to allow us establish a good understanding of the properties of the waste and proposed waste package, and;
- ii) Concept safety assessments - to compare the performance of the packaged waste against the safety, environmental and security assessments for transport and the operational and post-closure periods of a GDF.

The technical evaluations establish that the characteristics of the complete waste package (i.e. the waste container and the wasteform, their separate and conjoined characteristics) are understood in sufficient detail to form an effective basis for the concept safety assessments which are subsequently undertaken. This requires:

- an independent review of the radionuclide and physical/chemical inventory of the waste and, where necessary, augmentation to ensure that the assessment inventory is comprehensive and that any potential information 'gaps' have been addressed;
- determination of the expected performance of the waste package under normal and potential impact and fire accident conditions, based on waste package specific modelling or analogue data;
- prediction of the behaviour of the waste package under extended storage and disposal conditions.

The information produced during the technical evaluations is then used to 'test' the implications of the implementation of the packaging proposal against the safety, environmental and security assessments that have been carried out of transport and the operational and post-closure periods of a GDF. This is carried out by substituting the generic assumptions made regarding contents and performance of the waste packages for the waste stream proposed to be packaged with the 'real' real waste package characteristics determined during the technical evaluations.

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<sup>5</sup> It should be noted that the suitability of proposals for the operation of a facility for the interim surface storage of the waste packages produced by such a packaging facility would also be assessed as part of the same disposability assessment.

During the disposability assessment process we also review the status of the proposed waste packages from the perspective of various specialist functions which will influence the design and/or required characteristics of the waste package. Specialist inputs will be provided to:

- perform a non-radiological environmental assessment to provide the opportunity for a check that there are no aspects of the packaging proposal that are inconsistent with wider environmental protection considerations;
- review the status of the waste packages from the perspective of international Safeguards to ensure that they will be consistent with the Safeguards arrangements currently envisaged for a GDF;
- review the status of the waste packages from the perspective of physical security to ensure that they will be compliant with the security plan developed for transport and operations at a GDF;
- provide confirmation that the waste packager is meeting the requirements for quality management [10] and the recording of data pertaining to the waste packages during manufacture and storage [11]; and
- review the waste packaging proposal from the perspective of our assessment policy and principles and our environmental and safety policies.

During each of the stages of the disposability assessment process the disposability safety case will become progressively developed such that at the Final stage it is robustly supported by all necessary design and research and can be presented to the waste packager as a disposability case. In line with regulatory guidance [12] it is envisaged that the disposability case presented in the Final stage Assessment Report will be of sufficient quality and scope that it can be adopted by the site operator and incorporated into the overall safety case for the packaging plant.

### **2.3 Standard Waste Package Descriptions**

A SWPD is a full description of a disposable waste package in terms of a specific design of waste container and its contents. It is based on a specific design of waste package, which has been subject to a disposability assessment which has resulted in the disposability of the waste package being confirmed by way of the issue of a Final stage LoC. The production of a SWPD draws extensively on the outcomes of that assessment and, in particular, makes use of the Waste Product Specification (WPrS) which has been produced as part of the original packaging proposal.

A WPrS [13] is a document produced by the waste packager which describes the quality (i.e. the composition and properties) and performance characteristics of a distinct type of waste package produced in a waste packaging plant.

In order for a SWPD to constitute a complete description of a disposable waste package it must contain more information than would normally be found in a WPrS. Specifically a SWPD must comprise:

- A description of the waste container, including the specific design, method and material(s) of construction and any specific features including internal 'furniture'<sup>6</sup>;
- A full description of the contents of the waste package in terms of:
  - the waste itself, physical, chemical and radionuclide related properties; and

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<sup>6</sup> Such as waste/encapsulant mixing devices, dewatering tubes, waste baskets etc.

- the waste conditioning process, including any pre-treatments, the nature of encapsulating medium, process conditions etc., as will affect the properties of the wastefrom and waste package.
- The maximum allowable inventory of the waste package, in terms of both the radionuclides and the various ‘non-nuclear’ components of the waste (e.g. metals, organic materials etc.) including the materials used to condition the waste.

This information would need to be sufficiently detailed to allow the waste package performance characteristics (i.e. heat output, external dose, criticality safety, impact performance etc.) to be defined in such a way that compliance with the relevant generic specification (currently the GWPS [8] in the case of waste packages containing ILW) could be demonstrated.

The information that is defined by a SWPD is presented in the form shown in Appendix A.

It is our intention that following the issue of every Final stage LoC for a specific waste package design, a SWPD will be produced and added to a catalogue of SWPDs which will form part of the WPSGD. The catalogue is currently in its infancy and comprises only a small number of waste package designs which have been issued with a Final stage LoC and disposability case. We anticipate that the catalogue will grow over time to encompass a wider range of waste types and package designs<sup>7</sup>.

On the basis that a SWPD is the description of a disposable waste package, any proposed waste package that can be shown to be compliant with all of the features defined by that SWPD would also be disposable. Accordingly if such compliance can be demonstrated for a packaging proposal, the proposal can be endorsed in the same manner as would be forthcoming by way of a ‘conventional’ disposability assessment outline above, but without the need to carry out the full range of technical evaluations and concept safety assessments.

The actual procedure for the endorsement of a packaging proposal against a SWPD would be based on a waste packager demonstrating that all aspects of the proposed waste packages were bounded by a specific SWPD. This would involve the waste packager providing a full description of the physical, chemical and radiological properties of the waste to be packaged together with a definition of the maximum waste package inventory that would result from the proposed packaging process. This information would then be used to show whether the proposed waste packages are bounded by the SWPD, and therefore disposable.

RWMD’s involvement in the endorsement process, apart from the original definition of the SWPD, would then be limited to:

- Confirming the veracity of the inventory information provided by the waste packager.
- Ensuring that the proposed manufacturing processes are defined in such a manner to ensure that the declared maximum inventory cannot be exceeded.
- Confirming the adequacy of the waste packager’s proposed quality management systems and data recording arrangements.
- Confirming that the packaging proposal as a whole was compatible with the disposal concept safety assessments (i.e. for transport and the operational and post-closure periods of a GDF) and with RWMD policy for the disposal of waste in a GDF.

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<sup>7</sup> The current catalogue of published SWPDs can be found [here](#).

RWMD would also play a role in ensuring that waste packages are manufactured in accordance with the proposed processes, by way of the same audit process as is applied to all waste packaging operations.

The remainder of this guidance deals with the information that would be required from a waste packager as part of a submission for the assessment of the disposability of proposed waste packages against a SWPD.

### **3 Form and contents of a submission**

This section provides guidance on the type of information that will need to be included in a submission to permit a disposability assessment to be carried out against a SWPD. The section is laid out in such a manner as to allow it to be used as an outline guide to the structure of such a submission.

It should be noted that, although the discussion in this section and in Section 2 above sets out a formal assessment process, informal interactions between the waste packager, ourselves and the regulators, particularly early in project planning, are encouraged. Earlier discussions concerning project history and project plans, perhaps including site visits, will increase the level of understanding of the project and its constraints, and the requirements of all parties (i.e. the waste packager, RWMD, the regulators and stakeholders) and will improve the effectiveness and efficiency of the assessment process.

Appendix B provided a summary checklist for the contents of a submission, the detailed requirements being described below.

#### **3.1 Identification of the SWPD and confirmation of basic compliance**

As discussed above a SWPD is a complete description of a disposable waste package in terms of a specific design of waste container inside which a wasteform has been created using defined processes for a specific type of waste. Accordingly the first requirement for any submission will be the identification of the SWPD that is to be used by the waste packager as the basis for the submission. The waste packager will then be required to show that all of the relevant properties of the proposed waste packages will comply with those defined by the SWPD.

This section of the submission shall be concluded by a statement confirming compliance of the proposed waste packages with these three aspects of the SWPD, as outlined below.

##### **3.1.1 Waste container**

The SWPD will include a full description of the waste container on which it is founded. This will comprise a list of the drawing numbers and manufacturing specifications of a waste container that has already been subject to an evaluation as part of a Final stage disposability assessment.

The submission shall include a statement that this design of waste container, including any internal 'furniture', will be used for the manufacture of all waste packages covered by the packaging proposal.

Some modifications to the specified waste container design may be acceptable but these will have to be assessed on a case by case basis. It will therefore be necessary for the submission to include arguments to demonstrate that such modifications will not have any significant consequences for the overall performance of the waste package defined by the SWPD.

### 3.1.2 Waste

In order to enable us to ensure that the waste to be packaged is sufficiently similar, in terms of its physical, chemical and radionuclide properties, to that considered in the disposability assessment on which the SWPD is founded, a full understanding of the waste will be required. This will include information on the origin of the waste together with its storage arrangements since its arising.

To allow us to satisfy ourselves that the nature of the waste is adequately bounded by the SWPD the submission shall include a brief description of:

- the site, plant and processes that generated the waste;
- the current and historical storage arrangements for the waste;
- the history of the current project, including details of any preliminary optioneering work and restrictions placed on the project by the site infrastructure, the waste owner, regulatory requirements, etc. This shall include details of relevant Integrated Waste Strategy (IWS), Best Practicable Environmental Option (BPEO), Best Practicable Means (BPM) and ALARP studies.

The characteristics of the raw waste could significantly affect the ability of the proposed waste packages to be compliant with the SWPD, and therefore a good understanding of the physical and chemical characteristics of the waste is required. The submission shall therefore describe the physical characteristics of the waste (e.g. the nature of sludge, physical sizes of solids) and the major chemical components of the waste (e.g. types of solid materials, major species in sludges or liquids, organic compounds) including the expected or known inventory of chemically toxic species, such as heavy metals.

The GWPS lists a range of 'prohibited items' in wastes to be packaged, together with other materials and wastefrom properties which must be 'minimised' and others which must be 'made safe'. These general requirements will apply to all packaging submission unless the SWPD includes a quantified limit for any such items or materials. Accordingly the submission shall include statements indicating the absence of the following materials unless permitted by the SWPD, in which case the 'Nature and Quantities report' (see below) will be required to demonstrate compliance with the defined limit:

- free liquids;
- voidage;
- loose particulates;
- hazardous materials:
  - pyrophoric materials
  - oxidising materials
  - flammable liquids and gases;
  - explosive materials;
  - sealed and/or pressurised containers.
- materials that affect chemical containment:
  - oxidising agents;
  - acids;
  - cellulose and other organics
  - complexants and chelating agents;
  - non-aqueous phase liquids.



Some variations from the specified physical and chemical properties of the waste to be packaged may be acceptable but these will have to be assessed on a case by case basis. It will therefore be necessary for the submission to include arguments to demonstrate that such variations will not have any significant consequences for the overall performance of the waste package defined by the SWPD.

### **3.1.3 Waste conditioning processes**

The SWPD defines the waste conditioning processes that have been previously been shown to be capable of resulting in a wasteform with the necessary characteristics when applied to the defined type of waste. This may include pre-treatment(s) (e.g. size reduction, puncturing of sealed vessels, draining of liquids), encapsulant formulations and/or mixing processes.

The submission shall include a statement that the same conditioning processes and materials will be used during the manufacture of the waste packages covered by the packaging proposal.

Some modifications to the specified waste conditioning processes may be acceptable but these will have to be assessed on a case by case basis. It will therefore be necessary for the submission to include arguments to demonstrate that such modifications will not have any significant consequences for the overall performance of the waste package defined by the SWPD.

## **3.2 The 'Nature and Quantities' report**

The Nature and Quantities (N&Q) report is the key means by which compliance of the contents of the proposed waste packages can be shown as being compliant with the specified SWPD.

A required component of the N&Q report will be a set of waste package 'data sheets' which will summarise the expected total number and the estimated average and maximum expected contents of the waste packages that will result from the packaging proposal. These data sheets shall be produced using information on the waste, its origins (Section 3.1.2) and the proposed waste conditioning processes (Section 3.1.3). The report shall include a description of the basis for the determination of the values in the data sheets, including the uncertainties in the values.

The data sheets will be required to include all materials and radionuclides for which bounding values are defined by the SWPD. In the case of radionuclides, those listed in the SWPD shall be considered a bare minimum as the waste packager will be required to show that no other radionuclides are present in quantities that could be significant to the long-term management of the waste packages. Significance in this context shall be the same as that applied during the production of the SWPD in that they do not contribute more than 5% to:

- the total activity (in  $A_2$  units) content of the proposed waste packages;
- the total radiogenic heat output of the proposed waste packages; or
- the maximum external radiation dose rate of the proposed waste packages.

As well as including the radionuclides for which limits are defined by the SWPD, the data sheets shall also include the estimated average and maximum quantities of all other radionuclides which may impact on future periods of the long-term management of the proposed waste packages. These are defined as all of those of the 112 'relevant radionuclides' and which may be present in the proposed waste packages in quantities in excess of the 'Guidance Quantities' defined for the waste package design [14]. The actual quantities of these radionuclides in manufactured waste packages will also be required to be recorded as part of the data and information recording requirements (Section 3.7).

Additionally, the estimated average and maximum quantities of any fissile radionuclides not included in the SWPD, but which may be present in quantities of greater than 1g, shall also be included in the data sheets.

The N&Q report shall also include:

- the average and maximum total waste package activity content (in  $A_2$  units and in TBq for  $\alpha$ - and  $\beta\gamma$ -emitters) and radiogenic heat output;
- the physical form and expected distribution of fissile materials, and neutron reflectors and moderators, within the proposed waste packages;
- the relationship between the information provided in the submission and the information provided for the most recently published UK Radioactive Waste Inventory; and
- a statement regarding the Safeguards status of any nuclear materials in the waste and how ongoing arrangements for such materials will be handled.

The N&Q report shall conclude with a statement confirming the compliance by all of the proposed waste packages with all of the quantified criteria defined by the SWPD for waste package contents.

Some variations from the specified waste package contents may be acceptable but these will have to be assessed on a case by case basis. It will therefore be necessary for the submission to include arguments to demonstrate that such variations will not have any significant consequences for the overall performance of the waste package defined by the SWPD.

### **3.3 Waste Product Specification**

The WPrS is the specification developed by the waste packager which specifies the quality and performance characteristics of the waste packages that are to be produced in a waste packaging plant, by defining the key limits and controls that will be applied during waste package manufacture. This key document will eventually be used, together with other records etc, to demonstrate that waste packages meet the waste acceptance criteria for a GDF and are compatible with all future stages of waste management. It can also be used by an auditor to seek confirmation that the packaging process and resultant product are compliant with that endorsed by the assessment.

The structure and contents of the WPrS should be as defined for submission for a Final stage disposability assessment in the RWMD guidance on WPrS [13].

### **3.4 Criticality Compliance Assurance Documentation**

The purpose of the Criticality Compliance Assurance Documentation (CCAD) produced as part of a packaging proposal is to demonstrate that the waste packagers' arrangements for dealing with any fissile material in a waste stream will ensure the criticality safety of waste packages during all stages of their long-term management, including disposal. To prepare such a document, the author usually requires an in depth understanding of the waste, waste packaging plant, the control of and uncertainties in fissile materials determination and the potential for 'overbatching'.

The structure and contents of the CCAD should be as defined for submission for a Final stage disposability assessment in the RWMD guidance on the preparation of CCAD [15].

### **3.5 Description of interim storage arrangements**

Following manufacture it is important that waste packages are stored, for a period that could extend to many decades, in such a manner that will avoid any deleterious evolution.

The submission shall include a description of the proposed storage arrangements, including the arrangements for monitoring the condition of waste packages. Guidance on these two aspects of interim storage can be found in [16] and [17].

### **3.6 Arrangements for quality management**

In issuing LoCs it is important that we have confidence in the quality of the products and records to be produced during their production. The waste packager is therefore required to establish, implement and maintain a formal and effective quality management system (QMS) with the objective of assuring product quality and data records for the packaged waste. The QMS shall apply to all activities, interactions and aspects that can affect the product quality of the packaged wastes, including early project planning and development work. The QMS should also cover all aspects of waste package data and information recording and the preservation of such information. As a minimum, the waste packager's QMS shall also comply with BS EN ISO9001.

The form of the QMS shall be such as that which is required as part of a Final stage submission for a full disposability assessment. This shall include a description of the scope and status of the QMS, providing details of when objective evidence has been, and will in future be, provided through audit. An overview of the plant QMS structure and documentation (Quality Plans, Operating Instructions, etc) shall also be provided. Guidance on the preferred structure and requirements for QMS can be found in [10].

### **3.7 Arrangements for data and information recording and storage**

It is important that a full record of the manufacture and subsequent treatment of each waste package is produced and maintained and that it will accompany the waste package through its ongoing management up to and including disposal in a GDF. The information that should be incorporated into the package record, some of which may have been produced prior to the waste packaging process, is specified in [11]. The method(s) by which this information is obtained, together with how it will be recorded, stored and maintained, shall be outlined in the submission.

The methods of obtaining information on the radionuclide and physical/chemical contents of the waste stream and waste packages could include use of records of known provenance and reliability concerning the origins and history of the waste and their consignment into the current storage facility, observations during waste retrieval and packaging, radiometric measurements and other measurement techniques.

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## Appendix A Typical form of SWPD

SWPD Description			
<b>Waste Package Type</b>	500 litre drum	<b>Waste Stream Summary Description</b>	Metallic scrap
<b>Basic conditioning process</b>	BFS/OPC grout infilling	<b>Source LoC Reference</b>	TPC 15 232
Summary Description of Physical and Chemical Characteristics			
<b>Major components</b>	Stainless Steel: Cropped pipes, plate Mild Steel: Slings, chains, shear blades, pumps		
<b>Minor significant components</b>	Non-metals Fuel related dusts and sludge		
<b>Other physical information</b>	<b>Dimensions</b>	No dimension >990mm No two dimensions >700mm	
	<b>Masses</b>	<800kg single item	
	<b>Bulk Densities</b>	>3tm <sup>-3</sup>	
WASTE CONTAINER AND FURNITURE			
<b>Waste Container Type/Variant</b>	500 litre Drum. Existing design for use with WEP/THORP scrap (Dwg 0/NF/1157795)		
<b>Additional Furniture etc.</b>	Scrap basket (Dwg No. 5038221D0006, Revision B)		
WASTEFORM CHARACTERISTICS			
<b>Summary:</b>	Waste packaged in WEP using same process as for WEP/THORP Scrap: Grout in-filling without vibration		
<b>Estimated quantities</b>	<b>Waste:</b>	800kg	
	<b>Grout:</b>	775kg @ 4.5:1 BFS/OPC	
	<b>Capping:</b>	100kg @ 3:1 PFA/OPC	

MAXIMUM INVENTORY OF WASTE PACKAGE							
<b>Metals (kg)</b>							
<b>Al</b>	3	<b>Mg</b>	6	<b>Other (Specify)</b>	-		
<b>Steels (specify)</b>		<b>Mild</b>	800	<b>Stainless</b>	800		
<b>Non metals (kg)</b>							
<b>Organics/Plastics etc.</b>		<b>Total Cellulose</b>	10	<b>Total Other Organics</b>	10		
RADIONUCLIDE INVENTORY							
<b>All radionuclides (TBq)</b>							
$\alpha$	5E-01	$\beta\gamma$	8E+01	$A_2$	5E+02	<b>Heat Output</b>	2W
<b>H-3</b>	7E+00	<b>C-14</b>	9E-02	<b>Cl-36</b>	2E-05	<b>Co-60</b>	1E+00
<b>Sr-90</b>	1E+00	<b>Tc-99</b>	2E-03	<b>Cs-137</b>	2E+00	<b>Ra-226</b>	1E-11
<b>Others<sup>8</sup>:</b>		<b>Ni-63</b>	4E+01	<b>Se-79</b>	1E-05	<b>I-129</b>	1E-06
		<b>Pu-238</b>	7E-02	<b>Pu-240</b>	4E-02	<b>Pu-241</b>	1E+00
		<b>Am-241</b>	2E-01				
Fissile radionuclides and other materials related to criticality safety							
<b>Total U</b>	5kg	<b>U-235 enrichment</b>	2%	<b>Total Pu</b>	25g		
<b>U-235</b>	100g	<b>Pu-239</b>	20g	<b>Pu-241</b>	0.3g		
<b>Other Materials</b>	<b>Graphite</b>	10kg	<b>Be</b>	1kg	<b>D<sub>2</sub>O</b>	100g	
<b>Fissile Material Category</b>		<b>Transport</b>		Low Enriched Fissile Material			
		<b>GDF Operational</b>		Low Enriched Uranium			

<sup>8</sup> >5% of total activity (TBq or  $A_2$ ) or heat output, DBA dose etc.

## Appendix B Submission contents checklist

The Table below comprises a checklist that could be used as part of a quality plan for the preparation of a submission for a disposability assessment.

Submission topic area	Coverage
Waste origin, project history and plans	<p>The site, plant and processes which generated the waste</p> <p>The current and historical storage arrangements</p> <p>The history of the current project, including optioneering, IWS, BPEO, BPM</p> <p>Project plans</p> <p>Package physical/chemical and radionuclide composition and inventories which will arise from the proposed waste and packaging process</p>
Identification of SWPD	<p>Statements of compliance with basic requirements of SWPD:</p> <ul style="list-style-type: none"> <li>• waste container</li> <li>• waste</li> <li>• waste conditioning</li> </ul> <p>Identification of modifications or variations from the SWPD, together with arguments for their acceptability.</p>
N&Q report	<p>Waste package data sheets summarising:</p> <ul style="list-style-type: none"> <li>• expected total number of waste packages</li> <li>• average and maximum expected contents of waste packages</li> <li>• the basis for the values in the data sheets, including uncertainties</li> <li>• Identification of radionuclides present in significant quantities: <ul style="list-style-type: none"> <li>○ &gt;5% of total activity, heat output, external radiation dose rate;</li> <li>○ &gt;GQ for waste package type.</li> </ul> </li> <li>• quantities, form and expected distribution of fissile radionuclides;</li> <li>• relationship between the information provided in the submission and the UKRWI</li> <li>• Safeguards status of nuclear materials and arrangements for ongoing recording etc.</li> </ul> <p>Statement confirming the compliance by all of the proposed waste packages with all of the quantified criteria defined by the SWPD.</p> <p>Identification of variations and arguments for their acceptability.</p>

<b>Submission topic area</b>	<b>Coverage</b>
Waste packaging process	Proposed waste retrieval process and waste treatment processes to be applied prior to waste packaging WPrS CCAD Statements of compliance with RWMD requirements and guidance
Interim storage of waste packages	Description of interim storage facilities and environmental conditions Description of proposed waste package monitoring system
Quality management	Overview of the plant QMS Statements of compliance with RWMD requirements
Data and information recording	Methods to be applied to derive a waste stream and waste package physical/chemical and radionuclide inventory for recording Statements of compliance with RWMD requirements



## **Appendix C Glossary of terms used in this note**

### *activity*

The number of atoms of a radioactive substance which decay by nuclear disintegration each second. The SI unit of activity is the becquerel (Bq).

### *alpha activity*

Alpha activity takes the form of particles (helium nuclei) ejected from a decaying (radioactive) atom. Alpha particles cause ionisation in biological tissue which may lead to damage. The particles have a very short range in air (typically about 5 cm) and alpha particles present in materials that are outside of the body are prevented from doing biological damage by the superficial dead skin cells, but become significant if inhaled or swallowed.

### *becquerel (Bq)*

The standard international unit of radioactivity equal to one radioactive decay per second. Multiples of becquerels commonly used to define radioactive waste activity are:

kilobecquerels (kBq) equal to 1 thousand ( $10^3$ ) Bq

megabecquerels (MBq) equal to 1 million ( $10^6$ ) Bq

gigabecquerels (GBq) equal to 1 billion ( $10^9$ ) Bq

terabecquerels (TBq) equal to 1 trillion ( $10^{12}$ ) Bq

### *beta activity*

Beta activity takes the form of particles (electrons) emitted during radioactive decay from the nucleus of an atom. Beta particles cause ionisation in biological tissue which may lead to damage. Most beta particles can pass through the skin and penetrate the body, but a few millimetres of light materials, such as aluminium, will generally shield against them.

### *conditioning*

Treatment of a radioactive waste material to create, or assist in the creation of, a wastefrom that has passive safety

### *container*

The vessel into which a wastefrom is placed to form a waste package suitable for handling, transport, storage and disposal.

### *criticality*

A state in which a quantity of fissile material can maintain a self-sustaining neutron chain reaction. Criticality requires that a sufficiently large quantity of fissile material (a critical mass) be assembled into a geometry that can sustain a chain reaction; unless both of these requirements are met, no chain reaction can take place and the system is said to be sub-critical.

### *criticality safety*

A methodology used to define the conditions required to ensure the continued sub-criticality of waste containing fissile material.

### *disposability*

The ability of a waste package to satisfy the defined requirement for disposal.

### *disposability assessment*

The process by which the *disposability* of proposed waste packages is assessed. The outcome of a disposability assessment may be a *Letter of Compliance* endorsing the disposability of the proposed waste packages.

*disposal*

In the context of solid waste, disposal is the emplacement of waste in a suitable facility without intent to retrieve it at a later date; retrieval may be possible but, if intended, the appropriate term is storage.

*disposal facility (for solid radioactive waste)*

An engineered facility for the disposal of solid radioactive wastes.

*disposal system*

All the aspects of the waste, the disposal facility and its surroundings that affect the radiological impact.

*emplacement (of waste in a disposal facility)*

The placement of a waste package in a designated location for disposal, with no intent to reposition or retrieve it subsequently.

*enrichment (uranium)*

The proportion (usually expressed as a % of the total mass) of uranium-235 in uranium.

*Environment Agency (EA)*

The environmental regulator for England and Wales. The Agency's role is the enforcement of specified laws and regulations aimed at protecting the environment, in the context of sustainable development, predominantly by authorising and controlling radioactive discharges and waste disposal to air, water (surface water, groundwater) and land. The Environment Agency also regulates nuclear sites under the Environmental Permitting Regulations and issues consents for non-radioactive discharges.

*fissile material*

Fissile material is that which undergoes fission under neutron irradiation. For regulatory purposes material containing any of the following nuclides is considered to be 'fissile': uranium-233, uranium-235, plutonium-239 and plutonium-241.

*gamma activity*

An electromagnetic radiation similar in some respects to visible light, but with higher energy. Gamma rays cause ionisations in biological tissue which may lead to damage. Gamma rays are very penetrating and are attenuated only by shields of dense metal or concrete, perhaps some metres thick, depending on their energy. Their emission during radioactive decay is usually accompanied by particle emission (beta or alpha activity).

*geological disposal*

A long term management option involving the emplacement of radioactive waste in an engineered underground geological disposal facility or repository, where the geology (rock structure) provides a barrier against the escape of radioactivity and there is no intention to retrieve the waste once the facility is closed.

*geological disposal facility (GDF)*

An engineered underground facility for the disposal of solid radioactive wastes.

*half-life*

The time taken for the activity of a given amount of a radioactive substance to decay to half of its initial value. Each radionuclide has a unique half-life.

### *hazardous materials*

Materials that can endanger human health if improperly handled. As defined by the Control of Substances Hazardous to Health Regulations, 2002.

### *higher activity radioactive waste*

Generally used to include the following categories of radioactive waste: low level waste not suitable for near surface disposal, intermediate level waste and high level waste.

### *high level waste (HLW)*

Radioactive wastes in which the temperature may rise significantly as a result of their radioactivity, so this factor has to be taken into account in the design of storage or disposal facilities.

### *intermediate level waste (ILW)*

Radioactive wastes exceeding the upper activity boundaries for LLW but which do not need heat to be taken into account in the design of storage or disposal facilities.

### *Letter of Compliance (LoC)*

A document, prepared by RWMD, that indicates to a waste packager that a proposed waste package is compliant with the relevant packaging criteria and disposal safety assessments, and is therefore deemed to be compatible with disposal in a GDF.

### *low level waste (LLW)*

Defined as "radioactive waste having a radioactive content not exceeding 4 gigabecquerels per tonne (GBq/te) of alpha or 12 GBq/te of beta/gamma activity".

### *Managing Radioactive Waste Safely (MRWS)*

A phrase covering the whole process of public consultation, work by CoRWM, and subsequent actions by Government, to identify and implement the option, or combination of options, for the long term management of the UK's higher activity radioactive waste.

### *Nuclear Decommissioning Authority (NDA)*

The NDA is the implementing organisation, responsible for planning and delivering the GDF. The NDA was set up on 1 April 2005, under the Energy Act 2004. It is a non-departmental public body with designated responsibility for managing the liabilities at specific sites. These sites are operated under contract by site licensee companies (initially British Nuclear Group Sellafield Limited, Magnox Electric Limited, Springfields Fuels Limited and UK Atomic Energy Authority). The NDA has a statutory requirement under the Energy Act 2004, to publish and consult on its Strategy and Annual Plans, which have to be agreed by the Secretary of State (currently the Secretary of State for Trade and Industry) and Scottish Ministers.

### *nuclear material*

Fissile material or material that can be used to produce fissile material (i.e. source material). This includes all isotopes of uranium, plutonium and thorium, together with certain isotopes of neptunium and americium.

### *passive safety*

The need to provide and maintain a safety function by minimising the need for active safety systems, monitoring or prompt human intervention. Requires radioactive wastes to be immobilised and packaged in a form that is physically and chemically stable. The package should be stored in a manner that is resistant to degradation and hazards, and which minimises the need for control and safety systems, maintenance, monitoring and human intervention.

*plutonium (Pu)*

A radioactive element occurring in very small quantities in uranium ores but mainly produced artificially, including for use in nuclear fuel, by neutron bombardment of uranium.

*post-closure period (of a disposal facility)*

The period following sealing and closure of a facility and the removal of active institutional controls.

*quality management system (QMS)*

A quality management system is the overall system by which an organisation determines, implements and ensures quality.

*Radioactive Waste Management Directorate (RWMD)*

The NDA Directorate established to design and build an effective delivery organisation to implement a safe, sustainable, publicly acceptable geological disposal programme. It is envisaged that this directorate will become a wholly owned subsidiary company of the NDA. Ultimately, it will evolve under the NDA into the organisation responsible for the delivery of the GDF. Ownership of this organisation can then be opened up to competition, in due course, in line with other NDA sites.

*radioactivity*

Atoms undergoing spontaneous random disintegration, usually accompanied by the emission of radiation.

*radionuclide*

A radioactive form of an element, for example carbon-14 or caesium-137.

*safeguards*

Measures used to verify that nation states comply with their international obligations not to use nuclear materials (plutonium, uranium and thorium) for nuclear explosives purposes. Global recognition of the need for such verification is reflected in the requirements of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) for the application of safeguards by the International Atomic Energy Agency. Also, the Treaty Establishing the European Atomic Energy Community (the Euratom Treaty) includes requirements for the application of safeguards by the EC.

*UK Radioactive Waste Inventory (UKRWI)*

A compilation of data on UK radioactive waste holdings, produced about every three years. The latest version, for a holding date of 1 April 2007, was published in June 2008. It is produced by Defra and the NDA. It is the latest public record of information on the sources, quantities and properties of LLW, ILW and HLW in the UK. It comprises of a number of reports and additional detailed information on the quantities and properties of radioactive wastes in the UK that existed at 1 April 2007 and those that were projected to arise after that date.

*uranium (U)*

A heavy, naturally occurring and weakly radioactive element, commercially extracted from uranium ores. By nuclear fission (the nucleus splitting into two or more nuclei and releasing energy) it is used as a fuel in nuclear reactors to generate heat.

Uranium is often categorised by way of the proportion of the radionuclide uranium-235 it contains.

*waste container*

Any vessel used to contain a wasteform for disposal.

*wasteform*

The waste in the physical and chemical form in which it will be disposed of, including any conditioning media and container furniture (i.e. in-drum mixing devices, dewatering tubes etc) but not including the waste container itself or any added inactive capping material.

*waste package*

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

*waste packager*

An organisation responsible for the packaging of radioactive waste in a form suitable for transport and disposal.





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