Geological Disposal:
Specification for waste containers for the packaging of low heat generating waste

December 2016
Geological Disposal:
Specification for waste containers for the packaging of low heat generating waste

December 2016
Conditions of Publication
This report is made available under the Radioactive Waste Management Limited (RWM) Transparency Policy. In line with this policy, RWM is seeking to make information on its activities readily available, and to enable interested parties to have access to and influence on its future programmes. The report may be freely used for non-commercial purposes. However, all commercial uses, including copying and re-publication, require permission from the Nuclear Decommissioning Authority (NDA). All copyright, database rights and other intellectual property rights reside with the NDA. Applications for permission to use the report commercially should be made to the NDA Information Manager.

Although great care has been taken to ensure the accuracy and completeness of the information contained in this publication, the NDA cannot assume any responsibility for consequences that may arise from its use by other parties.

© Nuclear Decommissioning Authority 2016. All rights reserved.

Bibliography
If you would like to see other reports available from RWM and the NDA, a complete listing can be viewed at our website www.nda.gov.uk, or please write to our Communications department at the address below.

Feedback
Readers are invited to provide feedback to the RWM on the contents, clarity and presentation of this report and on the means of improving the range of reports published. Feedback should be addressed to:

Head of Stakeholder Engagement and Communications
Radioactive Waste Management Limited
Building 587
Curie Avenue
Harwell Oxford
Didcot
OX11 0RH
UK

email: rwmfeedback@nda.gov.uk
WASTE PACKAGE SPECIFICATION AND GUIDANCE DOCUMENTATION
SPECIFICATION FOR WASTE CONTAINERS FOR THE PACKAGING OF LOW HEAT GENERATING WASTE

Executive Summary
This document forms part of the Waste Package Specification and Guidance Documentation (WPSGD), a suite of documents prepared and issued by the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA). The WPSGD are intended to provide a ‘user-level’ interpretation of the RWMD packaging specifications, and other aspects of geological disposal, to assist UK waste producers in the development of plans for the packaging of higher activity waste in a manner suitable for geological disposal.

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

This document provides a specification for waste containers that can be used for the packaging of low heat generating waste for transport to and disposal in a geological disposal facility.

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

<table>
<thead>
<tr>
<th>WPSGD DOCUMENT NUMBER WPS/430 - VERSION HISTORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERSION</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>WPS/430/01</td>
</tr>
</tbody>
</table>
1 Introduction

The Nuclear Decommissioning Authority (NDA) has established Radioactive Waste Management Ltd (RWM) as the body responsible for implementing UK Government policy for the management of higher activity radioactive wastes, as set out in the 2014 Implementing Geological Disposal White Paper [1]. The White Paper outlines a framework for managing those wastes in the long-term through geological disposal, which will be implemented alongside the ongoing interim storage of waste packages and supporting research.

As implementer of a geological disposal facility (GDF), and therefore as the ultimate receiver of wastes for disposal, RWM will be responsible for establishing waste acceptance criteria (WAC) for such a facility. The plans for the construction of a GDF are at an early stage and the information necessary to define final WAC is not available. In the meantime, and as a precursor to WAC, RWM produces generic packaging specifications, the primary purpose of which is to enable the holders of radioactive wastes to condition that waste into a form that will be compatible with the anticipated needs of transport to and disposal in a GDF.

The packaging specifications, together with a wide range of explanatory material and guidance that users will find helpful in the development of proposals to package waste, make up a suite of documentation known as the Waste Package Specification and Guidance Documentation (WPSGD). For further information on the extent and the role of the WPSGD, all of which can be accessed via the RWM website, reference should be made to the Introduction to the RWM Waste Package Specification and Guidance Documentation [2].

The RWM packaging specifications form a hierarchy defined in such a manner to ensure that the needs of all users are satisfied. The Generic Specifications form the second tier of this hierarchy and are aimed at those involved in the development of concepts for the packaging of waste for geological disposal. They apply the high-level packaging requirements defined by the Generic Waste Package Specification [3] to waste packages containing a specific type of waste and are derived from the anticipated needs for the transport and geological disposal of waste packages containing such wastes. The requirements defined by a Generic Specification are applied to specific designs of waste package, manufactured using standardised designs of waste container, in the form of Waste Package Specifications (WPS).

This document is a specification for the required properties of the waste containers that can be used for the packaging of low heat generating waste\(^1\) (LHGW). The requirements specified herein are based on the high-level requirements for waste containers specified in the Generic Specification for waste packages containing low heat generating waste [4]. This specification should be read in conjunction with a number of other documents from the WPSGD, including:

(i) The Series 300 WPS (e.g. [5]);
(ii) Guidance on the achievement of the requirements for waste containers (as specified in this document [6]);
(iii) Guidance on the achievement of the requirements specified by the WPS [7, 8, 9];
(iv) The wasteform specification for waste packages containing LHGW [10]; and
(v) Guidance on the achievement of the requirements for wasteforms [11, 12]

\(^1\) This broad category of waste includes intermediate level waste and other wastes with similar radiological properties.
The suitability of specific designs of waste container to be used for the packaging of LHGW, such that they could be used to produce disposable waste packages, is assessed by way of the RWM Disposability Assessment Process [13]. Waste packagers intending to submit waste container designs for assessment by RWM are referred to Guidance on the preparation of submissions for the Disposability Assessment of waste packages [14].
2 Requirements for waste containers for the packaging of LHGW

Over the past few decades, the UK waste producers have developed plans for the packaging of a range of LHGW and, in some cases, have implemented those plans by manufacturing waste packages which have been shown to possess such properties that render them suitable for transport to and disposal in a GDF.

The development of plans for the packaging of low heat generating waste has resulted in the identification of a number of generic approaches to such packaging. This has included the definition of a number of standardised designs of waste container, each possessing such properties that will ensure the disposability of the waste packages they can be used to produce.

To date, the waste containers that have been used for the packaging of LHGW, or that are proposed to be used, fall into one of three basic types on the basis of how they deliver their functionality (i.e. for containment, radiation shielding etc.), and what kind of wastes they are to be used to package:

- Unshielded waste containers: Thin walled (i.e. a few mm) metal containers, typically made from stainless steel, and which may include internal shielding. Typically used to package LHGW with relatively high specific activities and significant quantities of fissile nuclides. Transported within robust transport containers.

- Shielded waste containers: Thick walled (i.e. up to ~100mm) reinforced concrete containers, with or without an outer thin-walled metal lining. Typically used to package LHGW with low specific activity and fissile nuclide content. Transport packages in their own right.

- Robust shielded waste containers: Thick-walled (i.e. up to a few 100mm) containers, typically made from cast iron. Suitable for the packaging of LHGW with a wide range of specific activities and fissile nuclide contents. Transported with or without a transport container.

The Disposal System Specification identifies a range of standardised designs of waste container which have been shown to be suitable for the packaging of LHGW for geological disposal [15]. Appendix A lists these waste containers, together with a brief description and references to the WPS that have been produce to specify the requirements for the waste packages they can be used to produce.

Whichever type of waste container and approach to waste conditioning is adopted for the treatment of a particular waste it will be the performance of the resulting waste package as a whole that will be used to judge its disposability. The fundamental aims for the packaging of waste are to ensure that the resulting waste packages are:

- passively safe and adequately physically robust, so as to ensure containment and safe handling during all ensuring phases of the long-term management of the waste including disposal at a GDF;
- suitable for safe transport through the public domain in compliance with the relevant regulations for such transport; and
- compatible with the safety cases for the operational and post-closure periods of a GDF.

The waste package provides the most immediate barrier to the release of radionuclides and other hazardous materials from the waste it contains, both during interim storage, transport and within a multiple barrier geological disposal system. It also plays a key role in
protecting individuals from the radiation emitted by the radionuclides it contains during interim storage, transport and the GDF operational period.

The barrier provided by a waste package can be considered to comprise two distinct components, each of which can act as a barrier in its own right:

- The waste container, which provides a physical barrier and also enables the waste to be handled safely during and following waste package manufacture. Containers can be manufactured from a range of materials with designs selected to suit the requirements for the packaging, transport and disposal of the wastes they contain.

- The wasteform, which can also provide a significant degree of physical and/or chemical containment of the radionuclides and other hazardous materials associated with the waste. The wasteform may comprise waste which has been 'immobilised' (e.g. by the use of an encapsulating medium such as cement) or that which may have received more limited pre-treatment prior to packaging (e.g. size reduction and/or drying).

Therefore, both the waste container and the wasteform contribute to the achievement of the required performance of the waste packages, with the relative importance of each generally depending on the robustness of the former. This is illustrated in Figure 1 which shows in stylised form how the use of a more robust waste container can reduce the required contribution of the wasteform to overall waste package performance.

Figure 1 also shows that for all waste packages both the waste container and the wasteform will be required to play some role. It should also be noted that it is the overall performance of the waste package, rather than that of its two components, that is the governing factor in judging its disposability. When defining the requirements for waste containers, it is the overall performance of the waste package that should be the basis for such definition rather than that of the waste container in isolation.

**Figure 1** Relative contribution of the waste container and wasteform to waste package performance

By considering the role played by the waste package as part of a multiple barrier geological disposal system the Disposal System Specification identifies a number of safety functions that must be achieved by waste packages destined for geological disposal. These may be
provided by the waste container or the wasteform, or by a combination of the two, and comprise:

- During transport and the GDF operational period:
  - provide containment of radionuclides during normal operations and under accident conditions;
  - limit radiation dose to workers and members of the public;
  - preclude criticality;
  - provide the means of safe handling; and
  - withstand internal and external loads.

- During the GDF post-closure period:
  - provide containment of radionuclides;
  - contribute to the overall performance of the EBS;
  - contribute to ensuring that, following GDF closure, a criticality event is not a significant concern; and
  - withstand internal and external loads.

To provide a basis for judging the ability of specific waste package designs to satisfy these safety functions, the packaging specifications define requirements for the 14 packaging criteria, as shown in Table 1.

**Table 1  Packaging criteria**

<table>
<thead>
<tr>
<th>External dimensions</th>
<th>Handling feature</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stackability</td>
<td>Durability of waste container integrity</td>
<td>Wasteform properties</td>
</tr>
<tr>
<td>Gross mass</td>
<td>Surface contamination</td>
<td>Activity content</td>
</tr>
<tr>
<td>Gas generation</td>
<td>External dose rate</td>
<td>Heat output</td>
</tr>
<tr>
<td>Criticality safety</td>
<td>Accident performance</td>
<td></td>
</tr>
</tbody>
</table>

Of the 14 criteria listed in Table 1, five are primarily functions of the waste container (identified by the use of *underlined italic type*) and a further seven (shown in *italic type*) are functions of the waste package as a whole and may rely at least partly on the properties of the waste container.

This Specification defines generic requirements for waste containers for the packaging of LHGW, derived from the Generic Specification for waste packages containing LHGW.
3 Specification for the properties of waste containers for LHGW

This section defines the high-level requirements on waste containers which are to be used to package LHGW. The specific requirements relating directly to the standardised designs of waste containers are defined in the relevant WPS, as listed in Appendix A.

3.1 External dimensions

The dimensions of the waste container shall be such that the external dimensions of the waste package will be compatible with the transport and GDF handling systems. The overall dimensions of a transport package should not exceed 6.058m x 2.438m plan x 2.591m high.

The dimensions of a transport package carried by rail shall not exceed 2.67m wide or 2.40m high.

Specific dimensional envelopes for the standardised designs of waste containers are defined in the relevant WPS.

3.2 Handling features

The waste container shall enable safe handling of the waste package by way of the transport and GDF handling systems.

The waste container shall incorporate lifting features to enable the waste package to be lifted without exhibiting any permanent deformation or abnormality that would render it non-compliant with any of the requirements defined in the relevant WPS.

Waste packages which are transport packages in their own right shall meet the requirements of the transport regulations. In the case of packages designed to meet the requirements of ISO 1496/1 [16] for ISO freight containers:

- the waste container shall incorporate corner fittings suitable for the gross mass of the waste package, and should be compliant with the relevant British and International Standards for Freight Containers [17]; and
- the waste package shall be capable of meeting the lifting test requirement defined by the relevant British and International Standards for Freight Containers [16], and should be capable of being lifted using two diagonally opposite lifting features where relevant.

For waste packages which are not transport packages in their own right, the waste container shall incorporate lifting features which enable the waste package to be lifted with a load equal to twice the weight of the waste package and, where the design of waste package incorporates more than three lifting points, it should be capable of being lifted using two diagonally opposite lifting features.

Where tie down within a conveyance is necessary for the safe transport of the waste package, the waste container shall incorporate tie-down features suitable for the maximum specified gross mass of the waste package.

The design of the waste container should enable remote handling of the waste package.

The definition and location of the handling features for standardised designs of waste containers are provided in the relevant WPS.
3.3 **Stackability**

Where required by the transport or disposal system, the waste container shall enable safe stacking of the waste package.

Waste packages which rely on their design to withstand stacking loads should be capable of being stacked with other waste packages of the same design, each with their maximum specified gross mass to a height of:

- 8.7 m, for waste packages handled using overhead cranes; or
- 11 m for waste packages handled using stacker trucks.

This loading shall not result in any permanent deformation or abnormality that would render it non-compliant with any of the requirements defined in the relevant WPS.

Waste packages which are transport packages in their own right shall comply with the stacking requirements defined by the IAEA Transport Regulations.

3.4 **Identification**

The waste package shall enable unique identification until the end of the GDF operational period.

The waste container shall be marked with a unique ten-digit alpha-numeric identifier at multiple locations as specified by the relevant WPS. The format of the alpha-numeric characters on the identifiers shall be as shown in Figure 2. The characters shall be between 6 mm and 10 mm high and shall comply with the RWM specification for waste package identification [18].

The waste package shall remain identifiable by automated systems for a minimum period of 150 years following manufacture.

**Figure 2** Format of waste package identifier

![Figure 2 Format of waste package identifier](image)

3.5 **Durability of waste container integrity**

The waste container shall enable safe handling of the waste package by way of its handling feature until the end of the GDF operational period.

The waste container shall maintain containment for as long as is required by the GDF safety case.

The integrity of the waste container shall be maintained for a period of 150 years and should be maintained for a period of 500 years following manufacture of the waste package.
3.6 Other requirements for waste containers

The properties of the waste container shall be such that, in conjunction with those of the wasteform, it satisfies all of the requirements for the waste package as defined by the Generic Specification for waste packages containing low heat generating waste [4]. This section introduces the packaging requirements which are a function of the waste package as a whole (as defined in Table 1) and identifies where the waste container may be required to contribute to achieving these requirements.

3.6.1 Maximum gross mass

The WPSs do not specify explicit limits on the mass of the waste container; however the gross mass of the waste package shall be compatible with the transport and GDF handling systems and with the requirement for the waste package to be safely stacked (see section 3.3).

Further restrictions may be applied to waste packages where they also constitute a transport package in their own right or where they are to be handled as part of combination of waste packages and a stillage (e.g. 500 litre drum waste packages).

3.6.2 External dose rate

The external dose rate from the waste package shall enable safe handling of the waste package during the transport and GDF operational period, and shall comply with regulatory limits for transport. The waste container should provide adequate radiation shielding, so that together with the wasteform, the waste package complies with all relevant external dose rate limits.

3.6.3 Heat output

The waste container should contribute to the overall thermal performance of the waste package under normal and accident conditions.

3.6.4 Surface contamination

The design of the waste container (i.e. geometric features, material of construction and surface finish) should be such as to facilitate decontamination of the waste package following manufacture.

3.6.5 Gas generation

The waste container shall enable the waste package to achieve the required performance with regard to the containment of radionuclides and other hazardous materials during normal operations and under accident conditions. This will include, where relevant, the venting of internally generated gases and the retention of activity in particulate form. Unvented waste containers should be sufficiently robust such that they are capable of withstanding the effects of internal pressurisation and of satisfying the requirements defined by the relevant WPS for retention of activity.

3.6.6 Criticality safety

The waste container should not include any feature that could deleteriously affect the criticality safety of the waste package.
3.6.7 Accident performance

The waste container should contribute to the overall performance of the waste package under impact and fire accident scenarios ensuring that:

- the release of radionuclides and other hazardous materials from the waste package is low and predictable and represents progressive release behaviour; and
- the impact and fire accident performance of the waste package complies with the assumptions that underpin the safety cases for transport and the GDF operational period.
Appendix A  Standardised containers for the packaging of LHGW

The Disposal System Specification [15] identifies a range of standardised designs of waste container for the packaging of LHGW. Each of these containers has been shown to be suitable for the manufacture of disposable waste packages.

The waste containers are grouped as discussed in Section 2, together with a reference to the relevant WPS for the waste packages that they can be used to manufacture.

A.1 Unshielded waste containers
For use with LHGW with higher specific activity, such as would generally require the use of remote handling techniques, waste containers typically made from thin-section stainless steel, can be used to create unshielded waste packages. Because of their high external radiation dose rate, or requirements for the containment of their contents, such waste packages would be expected to be transported through the public domain in reusable shielded transport containers, as Type B transport packages.

- WPS/300: 500 litre drum [5]
- WPS/310: Side-lifting variant of the 3 cubic metre box [19]
- WPS/315: Corner-lifting variant of the 3 cubic metre box [20]
- WPS/320: 3 cubic metre drum [21]
- WPS/340: Miscellaneous Beta/Gamma Waste Store box [22]

A.3 Shielded waste containers
For use with LHGW with low specific activity, such as would not generally require the extensive use of remote handling techniques, waste containers, typically made from thin section stainless steel or concrete, and incorporating integral radiation shielding\(^2\) can be used to create shielded waste packages. Such waste packages would generally be expected to be capable of being transported through the public domain without additional protection and would therefore qualify as transport packages in their own right.

- WPS/330: 4 metre box [23]
- WPS/350: 2 metre box [24]
- WPS/360: 6 cubic metre concrete box [25]
- WPS/361: 500 litre concrete drum [26]
- WPS/362: 1 cubic metre concrete drum [27]

A.2 Robust shielded waste containers
For all types of LHGW, thick-walled (i.e. many 10’s of mm) containers, typically made from ductile cast iron, can be used to provide both radiation shielding and physical containment of their contents, and to create robust shielded waste packages. Such waste packages are capable of being stored, transported and disposed of without the need for remote handling techniques or for additional shielding or containment.

- WPS/380: 500 litre robust shielded drum [28]
- WPS/362: 3 cubic metre robust shielded box [29]

\(^2\) If needed, to ensure that external radiation dose rates do not exceed the regulatory limits for transport.
References
