

**WASTE PACKAGE SPECIFICATION AND
GUIDANCE DOCUMENTATION**

**WPS/500: Wasteform Specification for
500 litre Drum Waste Package**

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Bibliography

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WASTE PACKAGE SPECIFICATION AND GUIDANCE DOCUMENTATION
WASTEFORM SPECIFICATION FOR 500 LITRE DRUM WASTE PACKAGE

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/500 - VERSION HISTORY

VERSION	DATE	COMMENTS
WPS/500/01	November 2005	Aligns with GWPS (Nirex Report N/104) as published June 2005
WPS/500/02	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. Includes changes related to updating of DBA methodology and changes to NII SAPs

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.

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.

In order to facilitate the safe and efficient packaging, transport and disposal of radioactive waste, RWMD has defined a limited range of standard waste containers. Included within the WPSGD are documents which define standards and specifications for the waste packages that are created using these containers, together with specifications for the wasteforms contained within them. For each standard waste package a suite of four documents exists:

- WPS/300 Series – Waste Package Specification
- WPS/500 Series – Wasteform Specification
- WPS/700 Series – Guidance on Waste Package Specification
- WPS/800 Series – Guidance on Wasteform Specification

This document provides a specification for the wasteform for the 500 litre Drum waste package and, as such, should be read in conjunction with *Specification for 500 litre Drum Waste Package, WPS/300* and the supporting information that can be found in *500 litre Drum Waste Package Specification: Guidance Material and Design Guidelines, WPS/700*.

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

Reference should also be made to *Wasteform Specification for 500 Litre Drum Waste Package: Explanatory Material and Guidance, WPS/800*, which provides background information, guidance and advice on the interpretation of this specification.

2 BACKGROUND

2.1 The Concept of Geological Disposal

A key aspect in the production of standard 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 facilities². 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;
- 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, in common with other approaches to the geological disposal of radioactive waste, 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 wasteform, 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 The generic description 'ILW' is used in the remainder of this document to describe both these categories of waste.

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.

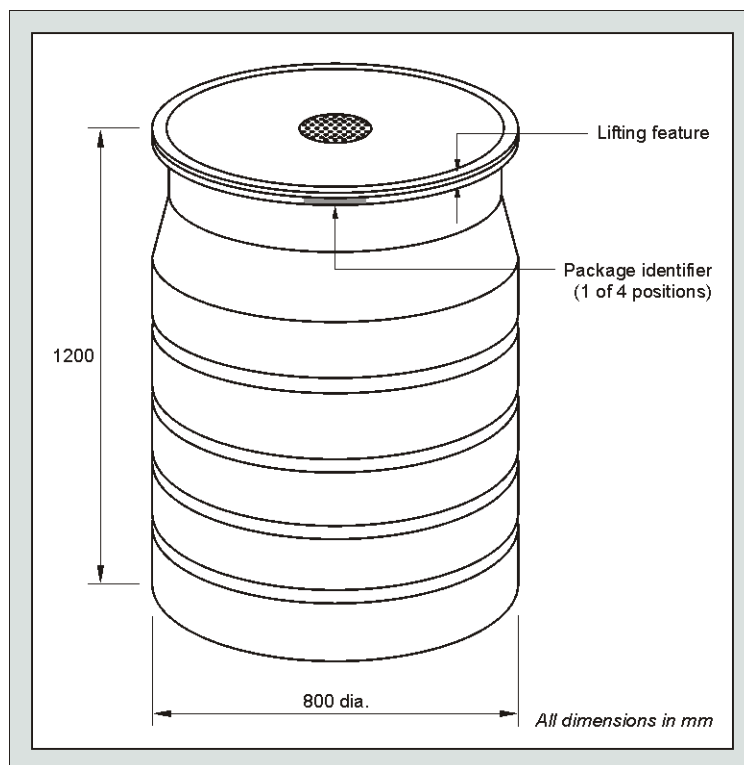
In April 2007 Nirex was dissolved and its responsibilities assumed by RWMD. This included the role of assessing and endorsing nuclear site operators' waste packaging proposals through the LoC assessment process.

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 THE 500 LITRE DRUM WASTE PACKAGE

The 500 litre Drum waste package (Figure 1) is one of a limited range of standard waste packages defined by the GWPS. It is the principal waste package used for the conditioning of ILW arising in the UK being used mainly for wastes arising from the day-to-day operations of nuclear facilities.

Figure 1 500 litre Drum Waste Package



It is an 'unshielded waste package' in that it is typically manufactured from relatively thin stainless steel and, because of either external radiation levels or requirements for the containment of radionuclides, remote handling is usually required. For similar reasons, 500 litre Drum waste packages are usually transported in a reusable shielded transport container, the combination of waste packages and transport container being classed as a Type B transport package under the IAEA Transport Regulations [5].

Within the standard dimensional envelope of the 500 litre Drum waste package, a number of variants have been developed to accommodate the process requirements for treating

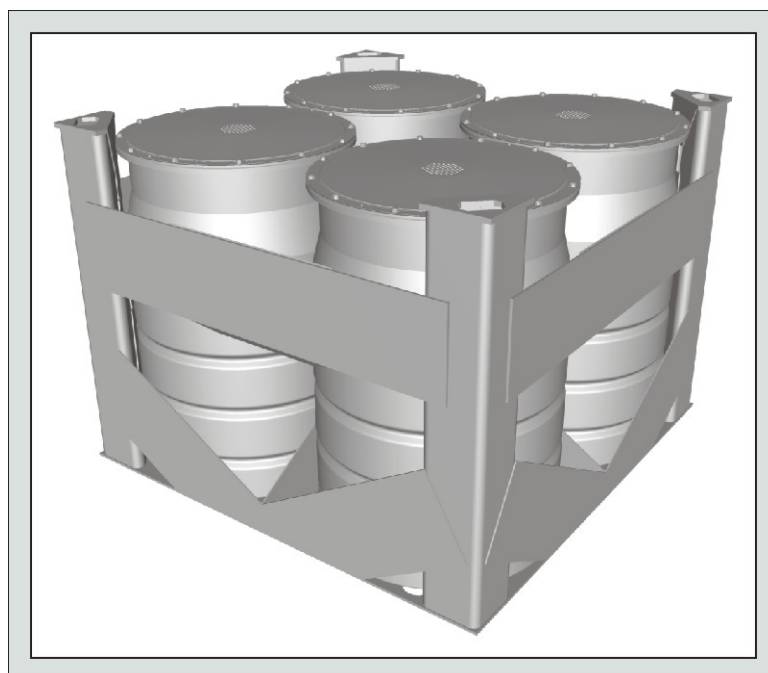
their diverse range of radioactive wastes. The three principal variants that have been developed are:

- 500 litre Solids Drum - for immobilised solid wasteforms.
- 500 litre Liquor Drum - for immobilised liquid, sludge and slurry wasteforms.
- 500 litre Annular Grouted Drum - for 'annular grouted' wasteforms, used for the packaging of 'super-compacted' storage drums (or 'pucks') and for wastes requiring additional physical protection and/or shielding.

Fuller descriptions of these variants can be found in the GWPS [1].

It is anticipated that, for most stages of their long-term management, 500 litre Drum waste packages will be handled using 'stillages' which will be designed to handle, lift and allow the stacking of 2 x 2 arrays of 500 litre Drum waste packages (Figure 2).

Figure 2 500 litre Drums in a stillage



4 SPECIFICATION OF WASTEFORM PROPERTIES

This Specification identifies the performance criteria that are required of the wasteforms for all waste packages manufactured using the 500 litre Drum waste container, to ensure the compatibility of such waste packages with the needs of all stages of their long-term management. Where numerical criteria are specified the values stated are those that would be applicable at the time of transport from the waste packager's site (unless specifically stated otherwise).

This Specification should be read in conjunction with *Specification for 500 litre Drum Waste Package, WPS/300* and the supporting information that can be found in *500 litre Drum Waste Package Specification: Guidance Material and Design Guidelines, WPS/700*.

Reference should also be made to *Wasteform Specification for 500 Litre Drum Waste Package: Explanatory Material and Guidance, WPS/800*, which provides background information, guidance and advice on the interpretation of this specification.

It should be noted that, where the words *shall* and *should* are used in criteria within this Specification, their use is consistent with the recommendations of BS 7373:1998 [6] and that they have the following meaning:

- *shall* denotes a criterion which is derived from consideration of a regulatory requirement and/or which forms the basis for package standardisation;
- *should* denotes a criterion which is considered as a target, and for which variations may be possible following discussion with RWMD.

4.1 Physical Immobilisation

The wasteform shall be designed to immobilise radionuclides and toxic materials so as to ensure appropriate waste package performance during all stages of long-term management. For many wastes, this immobilisation requires the use of an encapsulating matrix.

4.1.1 Immobilisation of Radionuclides and Particulates

All reasonable measures shall be taken to ensure that radionuclides and toxic materials in the waste are immobilised and that loose particulate material is minimised.

4.1.2 Response to an Impact Accident

All reasonable measures shall be taken to ensure that, in the event of an impact accident, the quantity of potentially mobile radionuclides present within the waste package, including those generated as a result of the impact accident, is commensurate with the waste package meeting the relevant radioactivity release limits specified in WPS/300.

4.1.3 Response to a Fire Accident

All reasonable measures shall be taken to ensure that, in the event of a fire accident, the quantity of potentially mobile radionuclides present within the waste package, including those generated as a result of the fire accident, is commensurate with the waste package meeting the relevant radioactivity release limits specified in WPS/300.

In addition, the wasteform should not readily burn or otherwise support combustion.

4.1.4 Free liquids

All reasonable measures shall be taken to exclude free liquids from the wasteform. This should include materials that may degrade to generate liquids. Free liquids not removed from wastes prior to waste packaging should be immobilised by a suitable waste conditioning process.

4.2 Mechanical and Physical Properties

The wasteform shall be designed to provide the mechanical and physical properties necessary to ensure appropriate performance of the waste package during all stages of long-term management.

4.2.1 Mechanical Strength

The wasteform shall provide sufficient mechanical strength to allow the waste package to be transported and handled without affecting the ability of the waste package to meet all the requirements of WPS/300.

4.2.2 Voidage

The development and production of the wasteform should ensure that the volume of voidage within the waste package (such as ullage, holes or other spaces) is minimised.

4.2.3 Mass-Transport Properties

The wasteform shall be sufficiently permeable to allow gases generated within the wasteform to be released without compromising the ability of the waste package to meet any aspect of WPS/300.

The mass transport properties of the wasteform (e.g. diffusivity and permeability) shall provide best practicable means for the containment of water-soluble radionuclides within the waste package.

4.2.4 Homogeneity / Uniformity

Local concentrations of materials within the wasteform that may compromise the ability of the waste package to meet any aspect of WPS/300 should be avoided.

4.2.5 Thermal Conductivity

The thermal conductivity of the wasteform shall be sufficient to dissipate any heat generated within the waste package, when emplaced in a GDF, without unacceptable temperature rise. The minimum value of thermal conductivity should be $0.5\text{Wm}^{-1}\text{K}^{-1}$.

4.3 Chemical Containment

The wasteform shall not be incompatible with the chemical containment of radionuclides and hazardous materials as embodied in the requirements of a GDF.

Where they may affect chemical containment, the following items should not be introduced through waste conditioning or packaging, and their presence in wastes should be minimised wherever practicable:

- Oxidising agents;
- Acids and/or materials that degrade to generate acids;
- Cellulose and other organic materials;

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- Complexants and chelating agents, and/or materials that degrade to generate such compounds;
- Non Aqueous Phase Liquids (NAPLs) and/or materials that degrade to generate them;
- Any other materials that could detrimentally affect chemical containment.

4.4 Hazardous Materials

The wasteform shall not contain hazardous³ materials, or have the potential to generate such materials, unless the treatment and packaging of such materials or items makes them safe. The means by which any of these materials is made safe shall be demonstrable for all relevant periods of long-term management.

4.5 Gas Generation

Gases generated by the wasteform shall not compromise the ability of the waste package to meet any aspect of WPS/300.

4.6 Wasteform Evolution

Changes in the characteristics of the wasteform as it evolves shall not result in degradation that will compromise the ability of the waste package to meet any aspect of WPS/300.

The deleterious effects of the following processes should be considered:

- dimensional changes, e.g. shrinkage;
- corrosion including, but not limited to, the production of gases and particulate material, and wasteform expansion resulting from the formation of lower density solid corrosion products;
- microbial activity;
- self-irradiation and irradiation by surrounding waste packages;
- heat generation by the wasteform and its surroundings including, but not limited to, localised heat sources within the wasteform, the effects on the curing of the encapsulant material and the consequential effects on longer-term performance.

4.7 Nuclear Properties

4.7.1 External Dose Rate

The radionuclide content and nature of the wasteform should ensure that waste package external dose rate limits as specified in WPS/300 are complied with at the time of transport.

4.7.2 Criticality Safety

The presence of fissile materials, neutron moderators and reflectors in the waste package shall be controlled to ensure that they do not present a criticality safety hazard during any of the active stages of their long-term management.

³ Including flammable, explosive, pyrophoric, chemo-toxic and oxidising materials; sealed and/or pressurised containers; and/or mechanical devices containing stored energy.

It shall also be ensured that, following closure of a GDF, the possibility of local accumulation of fissile material, such as to produce a neutron chain reaction, is not a significant concern to the long-term performance of a GDF.

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