GDF

WPS/300/05

Specification for Waste Packages Containing Low Heat Generating Waste Part D - Container Specific Requirements

Waste Package Specification and Guidance Documentation

November 2022

Nuclear Waste Services

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Executive Summary

This specification defines the key features for standard designs of waste containers used for the packaging of Low Heat Generating Waste (LHGW), and sets the minimum standards of performance for the waste packages they are used to produce. This is achieved through developing the requirements defined within the corresponding Part C Specification, WPS/220/01. There currently exist twelve standard designs of waste container, which are split into three categories, based on the type of waste package that they produce:

Unshielded Waste Packages	Shielded Waste Packages	Robust Shielded Waste Packages
500 L Drum	4 m Box	500 L Robust Shielded Drum
3 m^3 Drum	2 m Box	3 m^3 Robust Shielded Box
3 m^3 Box Side Lifting Variant	6 m^3 Concrete Box	
3 m^3 Box Corner Lifting Variant	500 L Concrete Drum	
Miscellaneous Beta Gamma Waste Store (MBGWS) Box	1 m^3 Concrete Drum	

There are requirements which waste packagers must demonstrate have been met at the time of packaging waste and some requirements which waste packagers must provide evidence to demonstrate that requirements will be met at a specified phase in the Geological Disposal Facility (GDF).

This document has been produced as the result of the consolidation of; WPS/300/03, WPS/310/04, WPS/315/05, WPS/320/04, WPS/330/03, WPS/340/01, WPS/350/03, WPS/360/03, WPS/361/01, WPS/362/01, WPS/380/01, and WPS/381/01. The document has also been updated in line with the revised Part C Specification to ensure the hierarchy of requirements is represented.

Contents

1 Introduction

1.1 Role of the Document

This Waste Package Specification (WPS) defines the properties and performance requirements for waste packages containing Low Heat Generating Waste (LHGW) produced from a range of standard waste container designs, all of which have been deemed acceptable for disposal in the illustrative concepts defined in the generic Disposal System Safety Case (gDSSC).

These requirements have been developed from those defined in the corresponding Part C Specification WPS/220/01 [1], which provides the envelope in which to develop waste packaging proposals that are compatible with current illustrative concepts and the generic safety case for all aspects (transport to, operation, and the post-closure) of a GDF.

It is noted that the requirements in this document do not explicitly apply to Depleted Natural Low Enriched Uranium (DNLEU). Some requirements can differ for DNLEU, and there exists a separate Specification for DNLEU WPS/230/01 [2].

This specification is referred to as '*Part D: Container Specific Requirements'*, and forms part of a suite of Waste Package Specifications (WPSs). It is designed to help inform the reader about how to package radioactive waste, when using one of the standard waste container designs. In addition, the document is used as part of the disposability assessment process to assess packaging proposals as described in Section 1.2.6.

1.2 Waste Package Specification and Guidance Documentation

1.2.1 Hierarchy of Requirements

This Part D Specification sits within a hierarchy of documents containing requirements, as shown in Figure 1.

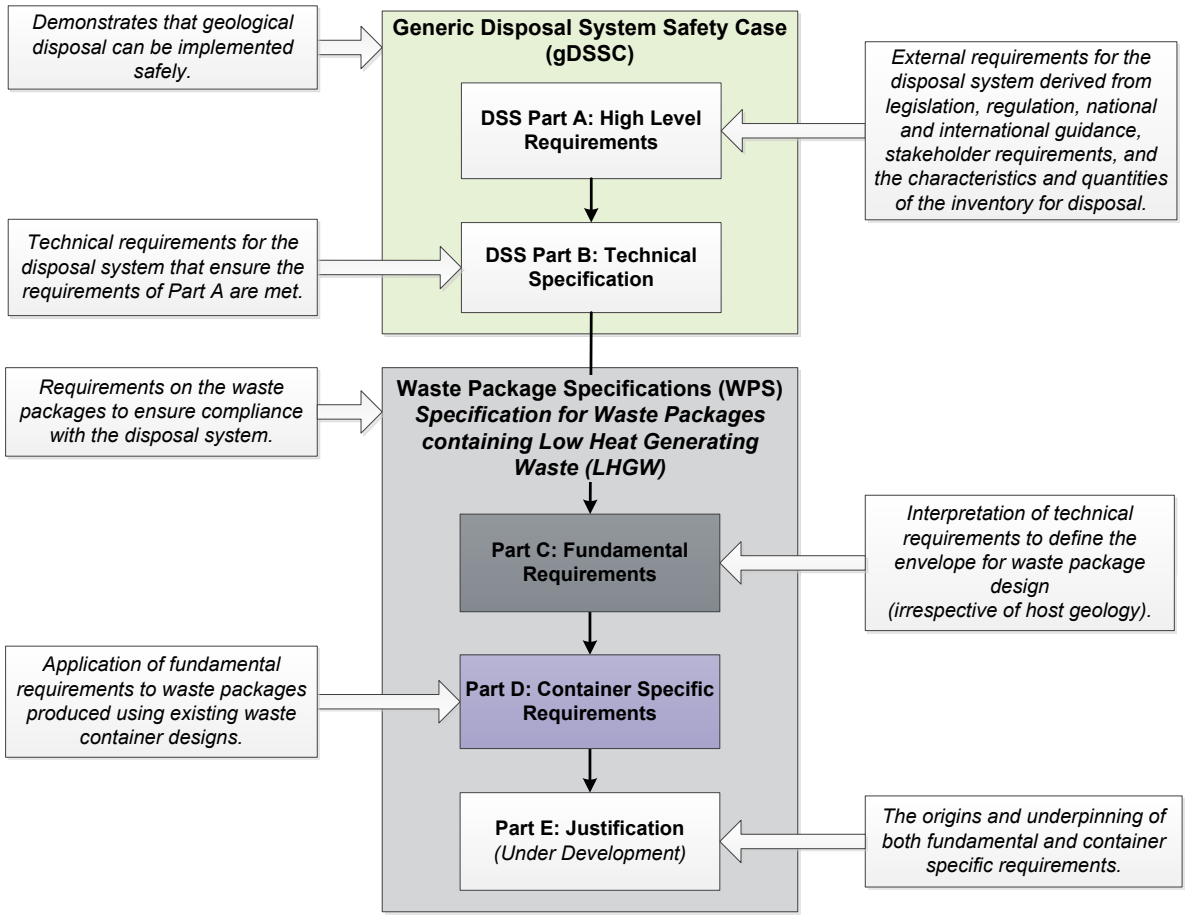

Figure 1 **Document hierarchy illustrating how the successive tiers of documents are organised and the requirements from the Disposal System Specification (DSS) and higher-level gDSSC link with those in the waste package specifications (WPS).**

To support safe delivery of a fully operational GDF, RWM has developed the gDSSC, which details the conceptual designs for a GDF and how they will ensure the safe long-term disposal of radioactive wastes. This includes the Disposal System Specification (DSS) Part A and Part B. An overview of the documents which make up the gDSSC is provided in DSSC/101/01 [3].

Examples of the requirements within this hierarchy, are shown in Figure 2, and address the following:

- **DSS Requirements:** While the DSS Part A, DSSC/401/01 [4], reflects external requirements, the DSS Part B, DSSC/402/01 [5], outlines the requirements for the disposal system to ensure compliance with Part A. Waste packages form part of this disposal system, and therefore these requirements are used as the highest level requirements in this document. These requirements are given the prefix 'B' and are formatted in **bold red** text.

- **Part C: Fundamental Requirements:** Apply the requirements from the DSS Part B to the design and production of waste packages. Compliance with the requirements in Part C is essential to ensure those in Part B are met [1]. These requirements are designated by the prefix 'C' and are formatted in **bold black** text.

- **Part D: Container Specific Requirements:** Apply to existing designs of container, which comply with the fundamental requirements as specified in the Part C. This specification describes existing waste container designs that can be used to produce disposable waste packages. These designs can be used as specified or may be modified to suit the waste packager's needs. These requirements are assigned the prefix 'D' and are formatted in **bold black** text.

  In this document the requirements are listed under the specific waste package criteria to which they relate. There are additionally summary sheets provided for each waste container design in the Appendices, alongside a list of abbreviations. A glossary of key terms used throughout this specification can also be located at the end of this document.

- **Part E: Justification:** Supports both Part C and Part D, by providing the associated background and underpinning for the requirements.
- **Supporting text and assumptions**: Plain text is used to provide supporting material relevant to the requirements. Assumptions are detailed in *purple italicised text*.

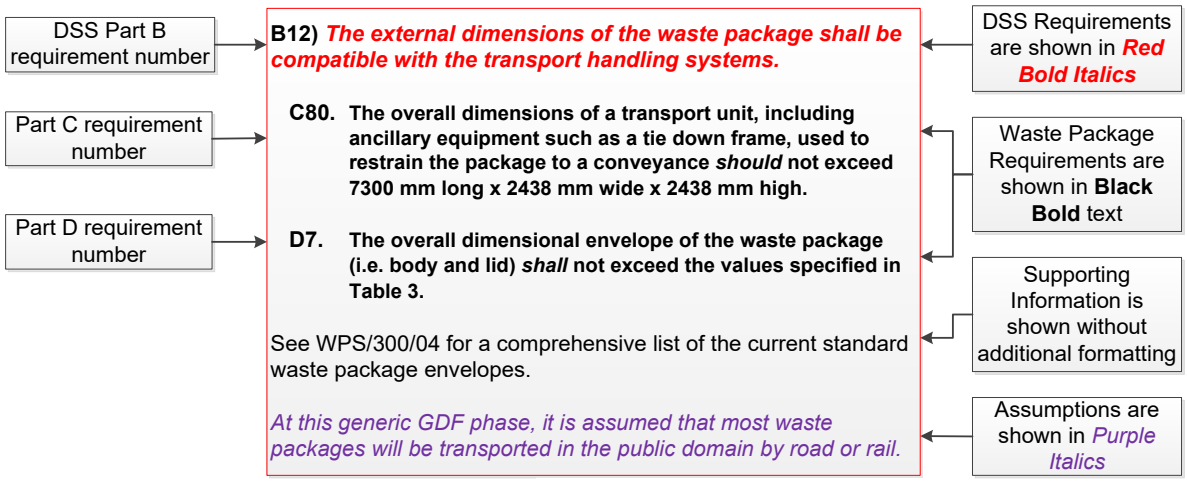

Figure 2 An example of how the requirements are formatted within the Part C and Part D Waste Package Specifications.

1.2.2 Waste Package Criteria

This specification defines the key features of the standard designs of waste containers and sets the minimum standards of performance for the waste packages that these containers produce. The requirements in this document are grouped under different waste package criteria (e.g. maximum gross mass, identification etc.). These requirements are applicable to the full lifecycle of the waste package, but, in some instances, are applied at particular times during the management of waste or to a GDF phase (transport, operations and post-closure).

Both the waste container and the wasteform are each considered as barriers that contribute to the performance of the overall waste package. In this specification, waste package criteria have been attributed to the component of the waste package which makes the most significant contribution to those criteria: waste container, wasteform or waste package. However, in all cases, it is the overall performance of the waste package, rather

than its individual components that is assessed during the disposability assessment process.

B11) ***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.***

There are also requirements that apply to waste packages during and after production, regarding records, quality, waste package assurance, and security, which are captured in the Part C specification.

1.2.3 How Part C and Part D Combine

To avoid repetition between the WPSs, requirements common to all waste packages are only captured in the Part C specification. The Part D specification contains only those requirements that are specific to existing waste container designs and must be used in conjunction with the Part C. Therefore, these specifications must be used together, as illustrated in Figure 3.

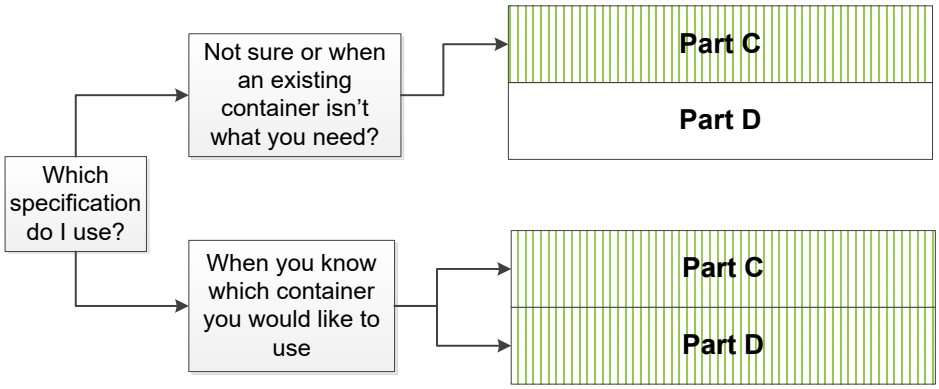

Figure 3 Decision making diagram illustrating an example of when to use the Part C and Part D specifications, as indicated by the green shading.

There is a common structure to the Part C and Part D specifications, as shown in Figure 3. Figure 3 also illustrates, using black text, where requirements have been further developed in the Part D specification such that they are specific to the standard range of waste container designs. Requirements for waste package criteria that need to be applied from the Part C are shown in blue.

1.2.4 Signposting to the Part C Specification

There are requirements for waste package criteria, which are not dependent on the waste package design and are common to all types of waste packages. These are defined within the Part C Specification [1], and to avoid duplication, are not repeated within this Part D specification. Table 1 identifies the relevant sections of the Part C Specification for each waste package criteria. The requirements in these sections must be applied in addition to and/or conjunction with the requirements in this (Part D) document.

Table 1 Waste package requirements listed within the Part C Specification relevant to standard designs of waste containers.

Category	Waste Package Criteria	Section Part C Specification	Supporting Guidance
Waste Container	Surface Contamination	6.1	-
	Stacking	6.2	
Wasteform	Properties and Evolution of the wasteform	7.2	WPS/502/01 [6], WPS/503/01 [7]
Waste Package	External Dimensions	8.1	-
	Gross Mass	8.2	
	Stacking	8.3	
	Identification	8.4	
	Handling Features	8.5	
	Durability	8.6	
	Heat Output	8.7	
	Surface Contamination	8.8	
	Voidage	8.9	
	Gas Generation	8.10	
	Groundwater Protection	8.11	
	Criticality Safety	8.12	WPS/916/01 [8], WPS/911/02 [9]
Assurance, Records and Management (ARM)	Management Systems	9.2	WPS/420/01 [10]
	Interim Storage	9.3	[11], [12], WPS/630/02 [13], WPS/640/02 [14]
	Nuclear Safeguards	9.4	WPS/923/01 [15]
	Nuclear Security	9.5	-
	Waste Package Records	9.6	WPS/850/03 [16], [17]

1.2.5 'Should' and 'Shall'

Aligning with the recommendations of BS 7373-1:2001 [18], and in-line with the approach taken in the DSS Part B [5], the waste package specifications use ***should*** and ***shall*** to denote targets and limits that each waste package is required to address:

- ***Shall*** denotes a hard limit.
- ***Should*** denotes a target.

Where ***shall*** is used, the limits cannot be exceeded. Where ***should*** is used, it denotes a target which can be exceeded if a suitable argument and justification can be made with the support of RWM through the disposability assessment process.

1.2.6 Disposability Assessment Process

Waste packagers must provide evidence to show they have and/or will meet the requirements in the WPSs to ensure that waste packages will be disposable in a GDF. Packaging proposals are assessed using RWM's Disposability Assessment Process, for which guidance is available in WPS/650/03 [19].

2 Types of Waste Containers and Waste Packages

2.1 Categorising Waste Packages

Waste packages containing LHGW are grouped into three types, with the following general characteristics as detailed below in Sections 2.1.1 – 2.1.3. Datasheets for the standard designs of waste container are contained in Appendices A-C and more information can be found in DSSC/441/01 [20].

How a waste package is transported and its role within the transport configuration can determine the applicability of some requirements. Within this specification, assumptions have been made about how waste packages will be transported and requirements have been applied based on these assumptions (described in Sections 2.1.1 to 2.1.3). However, it is worth noting that in certain instances, different transport configurations are available. More information regarding transport configurations is provided in Section 3.1.3, and the possible transport configurations for each waste package are indicated in Table 2.

2.1.1 Unshielded Waste Packages

These containers provide minimal shielding from the radiation emitted by their contents with such containers typically fabricated using relatively thin-section stainless steel.

The waste packages they are used to develop have the following features:

- Manufactured from relatively thin-walled steel.
- Handled using remote handling techniques.
- Requires transportation as part of a Type B transport package.

There are five standard designs of unshielded waste containers (as shown in Figure 4), included within this specification. They are as follows:

- **500 L Drum (Appendix A1):** Has been used for packaging of a wide range of wastes at a number of sites across the UK including, heterogeneous solid wastes in cementitious grout, homogeneous wastes mixed with an encapsulating medium and mixed 'soft wastes' compacted in sacrificial mild steel drums. These drums will be handled in a 2 x 2 array of 500 L Drum waste packages, within a stillage for both transport and disposal in a GDF. The stillage must meet additional requirements, which are specified in WPS/605/01 [21].

  500 L Drum waste packages will be handled, transported and disposed of using four-drum disposal stillages.

The drums will be transported within a stillage which will in turn be transported within a Standard Waste Transport Container (SWTC). Transport within the SWTC-285 has been assumed to determine the limits within this specification.

- **3 m^3 Drum (Appendix A2):** Generally used for the packaging of liquid, sludge and slurry wastes, which are typically conditioned by a process of in-drum mixing of the waste with an encapsulating medium. It is manufactured from stainless steel with a typical thickness of 3 mm.

  Transport within the SWTC-285 has been assumed to determine the limits within this specification.

- **3 m^3 Box (Appendix A3)**: The 3 m^3 Box is a cuboidal waste container typically used for the packaging of decommissioning wastes. There are two variants of this box which can be distinguished by the layout of their lifting features as follows:

  - The 'side lifting' variant has lifting and stacking features at the mid points of the sides of the waste container.
  - The 'corner lifting' variant has lifting and stacking features at the corners of the waste container.

  Transport within the SWTC-285 has been assumed to determine the limits within this specification.

- **Miscellaneous Beta Gamma Waste Store (MBGWS) Box (Appendix A4):** Cuboidal waste container which is currently used for the storage of a range of encapsulated solid LHGW at Sellafield site. Fabricated from either mild or stainless steel.

  Transport inside the SWTC-150 has been assumed to determine the limits within this specification.

Additional guidance is available for the use of unshielded waste packages in WPS/701/01 [22].

500 L Drum

3 m³ Drum

3 m³ Box Side Lifting Variant

3 m³ Box Corner Lifting Variant

MBGWS Box

Figure 4 Variants of standard designs of unshielded waste containers.

2.1.2 Shielded Waste Packages

The primary distinguishing feature of a shielded waste package is that it does not require additional (i.e. external) radiation shielding to allow both handling and transport. These waste containers include integral shielding, either in the form of a concrete liner, or provided by the walls of the container itself.

The waste packages they are used to develop have the following features:

- Incorporates radiation shielding, for example a concrete liner, where required.
- Intended to be transported as part of a Type IP-2 transport package.

There are five standard designs of shielded waste containers (as shown in Figure 5) included within this specification:

- **4 m Box (Appendix B1):** Used for the packaging of large waste items typically arising from the decommissioning of nuclear facilities. Typically constructed from thin-section stainless steel with a concrete liner to achieve a shielding thickness of up to 300 mm.
- **2 m Box (Appendix B2):** Used for the packaging of large waste items typically arising from the decommissioning of nuclear facilities. Typically constructed from thin-section stainless steel with a concrete liner to achieve a shielding thickness of up to 200 mm.
- **6 m³ Concrete Box (Appendix B3):** Can be used for the packaging of a range of solid heterogeneous wastes which are placed into the container and typically backfilled with cementitious grout. Generally manufactured from reinforced concrete. Walls are approximately 240 mm thick.
- **500 L Concrete Drum (Appendix B4):** Proposed to be used in the packaging of a wide range of power station operational wastes, including dewatered sludges, ion

exchange resins, filters and other heterogeneous solid wastes. Generally manufactured from reinforced concrete with wall thickness of approximately 150 mm. If required, further radiation shielding can be installed through the use of an inner steel liner.

- **1 m^3 Concrete Drum (Appendix B5):** Proposed to be used in the packaging of a wide range of power station operational wastes, including dewatered sludges, ion exchange resins, filters and other heterogeneous solid wastes. Generally, manufactured from reinforced concrete with walls approximately 150 mm in thickness. If required, further radiation shielding can be installed through the use of an inner steel liner.

These shielded waste packages will qualify as transport packages in their own right and will be classed as Type IP-2 transport packages.

For those made from concrete, the walls of the container can be produced such that they are gas permeable, avoiding pressurisation from any internally generated gases, and therefore, these waste containers may not require the incorporation of a specific engineered vent.

Associated guidance is available for this type of waste package in WPS/702/01 [23].

Figure 5 Variants of standard designs of shielded waste container.

2.1.3 Robust Shielded Waste Packages

These waste containers are sufficiently robust that the required performance of the waste package can be derived largely from the properties of the waste container. To date, the proposed designs of such waste containers are fabricated from ductile cast iron, and may have internal and external coatings of an epoxy polymer based paint, which serves to preserve the functionality of the components of the waste package. The waste packages they are used to develop have the following features:

- Manufactured from thick-walled (i.e. many 10's of mm thick) cast iron.
- May not require remote handling techniques.

- Can provide most or all of the necessary fire and impact protection for the waste during transport and GDF operations.

There are currently two standard designs of robust shielded waste containers (as shown in Figure 6) both with a range of wall thicknesses, included within this specification:

- **500 L Robust Shielded Drum (Appendix C1):** A cylindrical container manufactured with a range of wall thicknesses.

  The 500 L Robust Shielded Drum will be placed into a stillage, which in turn will be transported within the 150 mm design of SWTC. The SWTC will qualify as a Type B transport package.

- **3 m^3 Robust Shielded Box (Appendix C2):** A cuboidal waste container manufactured with a range of wall thicknesses.

  A range of transport arrangements exist for the 3 m^3 Robust Shielded Box:

  - *A 3 m^3 Robust Shielded Box transported within a Robust Shielded Box Transport Container (RSBTC) as a Type B(U) transport package, or*
  - *A 3 m^3 Robust Shielded Box transported within an International Standards Organisation (ISO) freight container, where the combination will be classified as a Type IP-2 transport package.*

500 L Robust Shielded Drum

3 m^3 Robust Shielded Box

Figure 6 Variants of standard designs of robust shielded waste containers.

2.2 Encapsulation and Non-Encapsulation

For the waste containers described in this document, it may or may not be necessary to encapsulate the waste.

For containers used to package waste that has been conditioned through the use of an encapsulating medium, the reader is directed to guidance on the production of encapsulated wasteforms in WPS/502/01 [24]. Some container types will be suitable to package some wastes without the use of an encapsulating medium. In this instance, the reader is directed to guidance on the production of non-encapsulated wasteforms in WPS/503/01 [25].

3 Transport of Waste Packages

Note, the majority of the requirements throughout this section are derived from the International Atomic Energy Agency (IAEA) *Regulations for the Safe Transport of Radioactive Material* [26] (hereafter referred to as the IAEA Transport Regulations) but do not replicate them in their entirety. The reader must refer to the IAEA Transport Regulations directly for the definitive set of requirements.

More information regarding how these regulations have been applied with the WPSs is provided in the Part C Specification [1], with only the key points summarised here.

3.1.1 Types of Transport Package

RWM's Transport Safety Case (TSC), DSSC/201/01 [27], assumes that waste packages will be stored at nuclear sites throughout the UK before being transported through the public domain to a GDF. The transport of radioactive materials is subject to a number of requirements implemented into UK law, notably those based upon the IAEA Transport Regulations.

The volumes and activities of the waste inventory indicate that transport to a GDF in either Type IP-2 and Type B transport packages will be most suitable. As a result, the requirements for these types of transport packages have been defined in this specification:

- Waste packages transported as Type B transport packages in their own right, or as part of a Type B transport package, allow transport of wastes with higher activity. For waste packages that are not Type B transport packages in their own right, RWM has developed a range of transport containers, the SWTCs and an RSBTC, in which to transport them. These provide radiation shielding, containment of activity, and confinement of fissile material in normal and accident conditions of transport. There are currently three designs of SWTC envisaged, providing nominal shielding thicknesses of 70 mm, 150 mm and 285 mm of steel with a density of 7700 kg m^{-3}.

- Waste packages transported as Type IP-2 transport packages, or as part of a Type IP-2 transport package, allow transport of materials with limited specific activity. This class of transport package is applicable to waste packages that satisfy the requirements of the IAEA Transport Regulations without the necessity for additional protection. Waste packages classified as Type IP-2 transport packages are often described as 'transport packages in their own right'. However, variations are possible and this classification can be applied to waste packages transported in Type IP-2 transport containers. This transport classification limits the radioactive contents of the waste package (i.e. the wasteform) in order to satisfy the requirements for low specific activity (LSA) material and surface contaminated objects (SCO).

3.1.2 Conditions of Exclusive and Non-Exclusive Use

Transport packages can be transported under the conditions of either exclusive or non-exclusive use [27]. However, the limits within this specification are based on transport taking place under the conditions of exclusive use.

Amongst other allowances, transport conditions of exclusive use remove the constraint on radiation levels to meet a Transport Index of 10 (a number used to afford control of radiation exposure as defined in Para 244 of the IAEA Transport Regulations [26]), for a transport package or overpack. It also permits the shipment of LSA-III material in an IP-2 transport package and the adoption of a 45 g fissile nuclide limit per conveyance for transport (under fissile exception).

The reader is directed to the Part C Specification [1] for an indication of the requirements for transport under the conditions of non-exclusive use.

3.1.3 Transport Configurations

To apply the requirements for transport to a waste package, the role and function of items within the transport configuration must be determined. Consideration must be given to the following:

- Where a waste package is handled in its own right during transport, the IAEA Transport Regulations apply directly to the waste package.
- Where a transport container is used, the waste package contributes to meeting the IAEA Transport Regulations [26], as demonstrated through compliance with the transport container design's contents specification (See Section 3.1.4).
- Where a waste package is a transport handling unit in its own right, the transport system handling requirements apply directly to the waste package.
- Where a transport container or overpack is used, the waste package must be compatible with the packing requirements of the transport container or overpack.

In certain instances, different transport configurations for a waste package are available. The anticipated variations in transport configuration for each waste package are described in Table 2. For the purpose of this specification, limits have been derived based on one transport configuration for each waste package, with the exception of 3 m^3 Robust Shielded boxes as indicated in Table 2, and specified as an assumption in Section 3.2.

3.1.4 Contents Specifications

All certified transport packages have a contents specification which defines the permitted radionuclide contents, in terms of activity, within such a transport package. RWM are the current Design Authority for several of these transport packages and, therefore, own the contents specifications (as references in Table 2). This is additionally the case for the range of SWTCs and RSBTC.

For a number of waste packages, the transport package Design Authority will be a third party. In these instances, demonstration that the waste package is consistent with the transport package's design substantiation is required, and those limits may be more constraining than those specified in this WPS.

In the case of both the 2 m and 4 m Boxes, which are transport packages in their own right, RWM has developed contents specifications for these transport packages as a precursor to their onward development by a waste packager or third party. For more information regarding Design Authorities and contents specification held by third parties, the reader is directed to contact RWM.

C33. A Contents Specification Document *should* be developed to define the contents limits for a transport package.

Table 2 Transport configurations for the standard designs of LHGW-containing waste containers and waste packages.

Type	Waste Package	Classification when The Waste Package is the Transport Package	Classification when the Waste Package is transported in a Transport Container		Overpack	Transport Handling Unit	Contents Specification where RWM is the Design Authority	Configuration assumed within this specification (marked with an (X)
			Transport Container	Package Type				
Unshielded	500 L Drum	N/A	SWTC-70	Type B	N/A	SWTC	[28]	-
			SWTC-285	Type B	N/A	SWTC	[29]	X
	3 m^3 Drum	N/A	SWTC-70	Type B	N/A	SWTC	[30]	-
			SWTC-285	Type B	N/A	SWTC	[31]	X
	3 m^3 Box	N/A	SWTC-70	Type B	N/A	SWTC	[32], [33]	-
			SWTC-285	Type B	N/A	SWTC	[34], [35]	X
	MBGWS Box	N/A	SWTC-150	Type B	N/A	SWTC	[36]	X
Shielded	4 m Box	Type IP-2	N/A	N/A	N/A	Waste Package	[37]	X
	2 m Box	Type IP-2	N/A	N/A	N/A	Waste Package	[38]	X
	6 m^3 Concrete Box	Type IP-2	N/A	N/A	N/A	Waste Package	N/A	X
	500 L Concrete Drum	Type IP-2	N/A	N/A	Overpack	Overpack	N/A	X
	1 m^3 Concrete Drum	Type IP-2	N/A	N/A	Overpack	Overpack	N/A	X
Robust Shielded	500 L Robust Shielded Drum	N/A	SWTC-150	Type B	N/A	SWTC	N/A	X
			ISO Freight Container	Type IP-2	N/A	ISO Freight Container	N/A	-
		Type B	N/A	N/A	Overpack	Overpack	N/A	-
		Type IP-2	N/A	N/A	Overpack	Overpack	N/A	-
	3 m^3 Robust Shielded Box	N/A	ISO Freight Container	Type IP-2	N/A	ISO Freight Container	N/A	X
		Type IP-2	N/A	N/A	Overpack	Overpack	N/A	-
		N/A	RSBTC	Type B	N/A	RSBTC	[39]	X

3.2 Activity Content

The maximum activity content of the waste package is generally determined by the limits on the contents as specified within the IAEA Transport Regulations [26].

3.2.1 Type B Transport Packages

The following requirement is derived from the IAEA Transport Regulations Para 660:

C30. For Type B transport packages that are not designed to meet the enhanced immersion test, the total activity content of the transport package *shall* not exceed 10^5 A_2.

The SWTCs referenced in this specification have all been certified against this test, and therefore, this requirement does not apply where these are utilised in the transport configuration. The RSBTC has yet to be certified against this requirement. However, the activity limit of the 3 m^3 Robust Shielded Box when transported within an RSBTC is expected to be below the 10^5 A_2 limit as set by the contents specification [39].

3.2.2 Type IP-2 Transport Packages

The following requirement is derived from the IAEA Transport Regulations Para 521:

C31. The contents of waste packages transported as part of a Type IP transport package, or as Type IP transport packages in their own right, *shall* be capable of being categorised as low specific activity (LSA) material or as surface contaminated objects (SCO).

This is supported by the following requirements as defined by Para 409, Para 409 and Para 522 respectively:

D1. The average specific activity of the wasteform *shall* not exceed $1x10^{-4}$ A_2/g for LSA-II material, in which the activity is distributed throughout solid radioactive material; or,

D2. The average specific activity of the wasteform *shall* not exceed $2x10^{-3}$ A_2/g for LSA-III material, in which the activity is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent.

D3. The total quantity of LSA material (LSA-II and LSA-III) in the form of combustible solids *shall* not exceed 100 A_2.

As derived from the IAEA Transport Regulations Para 517:

C32. The quantity of LSA material or SCO in the transport package *shall* be restricted such that the external radiation level at 3 m from the unshielded waste does not exceed 10 mSv/hr.

This is supported by the following requirements as defined by Para 409b and Para 409 respectively:

D4. Other material in which the activity is distributed throughout and the estimated average specific activity does not exceed 10^{-4} A_2 g^{-1} for solids and gases for LSA-II material.

D5. The radioactive material is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent for LSA-III.

4 Wasteform Requirements

B21) ***The properties of the wasteform shall comply with the requirements for containment within the geological disposal concept, as defined by the GDF safety case.***

At the highest level, the wasteform meets this containment function through ensuring that radionuclides and hazardous materials are immobilised. This is often achieved through a stable, low-solubility matrix.

The requirements of the wasteform can be sub-divided as follows:

- **Properties of the Wasteform:** Through placing controls on the properties of the wasteform, it is ensured that it will possess the desired properties for containment. These are further divided into physical, chemical, biological, and radiological properties.

- **Evolution of the Wasteform:** Required to ensure that the required properties of the wasteform are maintained over time.

The requirements placed on the properties and evolution of the wasteform, for LHGW, are not specific to the waste packages within this specification. The reader is directed to the Part C Specification [1], for the full range of wasteform requirements. However, where the properties are specific to one of the standard designs, the requirements are subsequently discussed in Section 4.1 of this document.

Limits on the activity of the waste package are specific to the intended transport configuration of each waste package type, and are therefore discussed in Section 3.2.

4.1 Properties and Evolution of the Wasteform

In general, the mechanical strength of the waste package comes from the mechanical strength of the waste container. The exception to this is the $3m^3$ Drum, in which the stacking features of the container are such that there is reliance on some support from the wasteform.

D6. The wasteform in a $3m^3$ Drum *shall* contribute to the mechanical strength of the waste package to ensure it can be transported, handled and stacked.

5 Waste Package Requirements

5.1 External Dimensions

B12) ***The external dimensions of the waste package shall be compatible with the transport handling systems.***

B13) ***The external dimensions of the waste package shall be compatible with the GDF handling systems.***

C80. The overall dimensions of a transport unit, including ancillary equipment such as a tie down frame, used to restrain the package to a conveyance *should* not exceed 7300 mm long x 2438 mm wide x 2438 mm high.

D7. The overall dimensional envelope of the waste package (i.e. body and lid) *shall* not exceed the values specified in Table 3.

The stated dimensions account for any associated furniture (where applicable). Further information regarding the dimensions (including tolerances) of the shielded box waste packages can be found in the associated guidance document, WPS/702/01 [23].

Table 3 Maximum dimensional envelope for standard waste container designs.

Waste Container	Maximum External Dimensions / mm	
	Height	Diameter or Length x Width
Unshielded Waste Packages		
500 L Drum	1230	800
3 m^3 Drum	1245	1720
3 m^3 Box	1245	1720 x 1720
MBGWS Box	1372	1853 x 1853
Shielded Waste Packages		
4 m Box	2200	4013 x 2438
2 m Box	2200	1969 x 2438
6 m^3 Concrete Box	2200	2210 x 2438
500 L Concrete Drum	1302	1102
1 m^3 Concrete Drum	1302	1402
Robust Shielded Waste Packages		
500 L Robust Shielded Drum	1520	1070
3 m^3 Robust Shielded Box	1740	2010 x 1610

5.2 Maximum Gross Mass

B24) ***The gross mass of the waste package shall be compatible with the transport system.***

C85. The overall mass of a waste package in its transport configuration *should* not exceed 65,000 kg.

D8. The gross mass of the waste package *shall* not exceed the values specified in Table 4.

Table 4 Maximum gross mass for standard waste package designs.

Waste Package	Maximum Gross Mass / t
Unshielded Waste Packages	
500 L Drum	2
3 m^3 Drum	8
3 m^3 Box	12
MBGWS Box	12
Shielded Waste Packages	
4 m Box	65
2 m Box	40
6 m^3 Concrete Box	50
500 L Concrete Drum	6
1 m^3 Concrete Drum	8
Robust Shielded Waste Packages	
500 L Robust Shielded Drum	10
3 m^3 Robust Shielded Box	25

5.3 Stacking

B16) ***Where required by the transport or disposal system, the waste package shall enable safe stacking.***

C87. Disposal units *shall* be capable of being stacked with other disposal units of the same type, each with their maximum specified gross mass, not resulting in any permanent deformation or abnormality that would render them non-complaint with any other performance requirements defined within this specification, to a maximum height of:

a. 8.8 m for waste packages handled using overhead cranes.

b. 11 m for waste packages handled using top loading stacker trucks.

5.3.1 Stacking During Transport

D9. Waste packages which are transport packages in their own right *shall* be capable of withstanding a compressive load equal to five times the maximum mass of the same waste package type.

5.3.2 Stacking During GDF Operations

D10. The waste package *shall* be capable of supporting a mass as specified in Table 5, applied along the vertical axis of the waste package.

Table 5 Maximum total mass a waste package is expected to support through its vertical axis.

Waste Package	Maximum Mass to Support / t	Maximum Stack Height
Unshielded Waste Packages		
3 m^3 Drum[1]	48	7
3 m^3 Box	72	7
MBGWS Box	60	6
Shielded Waste Packages		
4 m Box	260	5
2 m Box	160	5
6 m^3 Concrete Box	200	5
500 L Concrete Drum	36	7
1 m^3 Concrete Drum	48	7
Robust Shielded Waste Packages		
500 L Robust Shielded Drum	20	3
3 m^3 Robust Shielded Box	50	3

[1]*The stacking feature of this waste package relies on some support from the wasteform. Refer to Section 4.1.*

The total mass that a waste package type is expected to support (as defined in Table 5) is calculated:

- Using the maximum stack height for each waste package type. *This is based on stacking in vaults in higher strength rock as described in the Geological Disposal Facility Design (GDFD) [40].*

- For a waste package at the bottom of the stack, assuming that *any waste package of its type could be at the bottom of the stack*.

- Applying the maximum gross mass of each waste package type, as specified in Section 5.2.

For example, as shown in Table 5, 3 m^3 Boxes will be stacked seven high, and therefore, the 3 m^3 Box at the bottom of the stack will have to withstand the load of six 3 m^3 Boxes.

5.4 Identification

B17) ***The waste package shall enable unique identification until the end of the GDF operational period.***

C90. The waste package *shall* be marked with a unique RWM identifier.

C91. Each identifier *shall* be at four defined locations to be agreed by RWM.

C95. The characters *shall* be of the Optical Character Recognition A form (OCR-A), as specified by BS 5464: Part 1, each with a height of between 6 and 10 mm.

C.96. The waste package identifier *shall* comprise three Data Fields which are contained within the ten alpha-numeric character sequence (Figure 7).

Additional requirements concerning the format of the Data Fields can be found in Part C, with associated guidance in WPS/860/03 [41].

D11. The identifier *shall* be located as specified in Table 6.

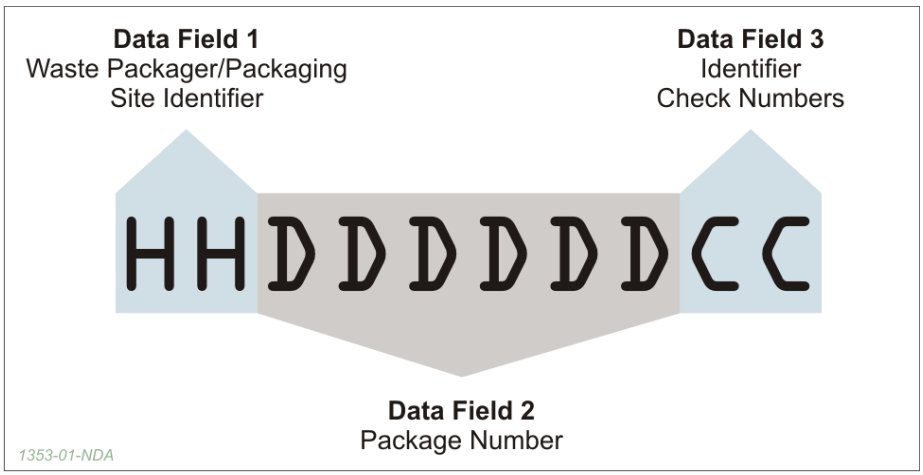

Figure 7 Format of RWM alpha-numeric waste package identifier.

Table 6 Location of identification markers on the standard waste package designs.

Waste Package		Location
Unshielded Waste Packages		
500 L Drum		**At four positions on the vertical surface of the lifting feature on the waste container body and spaced at 90º around the circumference of the waste container (as shown in Figure 9 in Appendix A1).**
3 m^3 Drum		**On each vertical surface of the waste container, at the mid-point of each lifting feature, the centre line being located 50 mm down from the top edge of the waste container (as shown in Figure 11 in Appendix A2).**
3 m^3 Box	Side Lifting Variant	**At the mid-point of each of the waste container lifting features, the centre line being located 50 mm down from the top edge of the waste container (as shown in Figure 13 in Appendix A3).**
	Corner Lifting Variant	**At the mid-position on the vertical surface of each right hand lifting feature (as shown in Figure 14 in Appendix A3).**
MBGWS Box		**On each vertical surface of the waste container, 505 mm from the centre line and of 720 mm up from the bottom edge of the waste container (as shown in Figure 16 in Appendix A4).**
Shielded Waste Packages		
4 m Box		**At the mid-point of each of the vertical surfaces of the waste container, on the centre line of each stacking post and located at a height of 700 mm from the lower surface (as shown in Figure 18 in Appendix B1 for the 4 m Box and in Figure 20 in Appendix B2 for the 2 m Box).**
2 m Box		
6 m^3 Concrete Box		**At the mid-point of each of the vertical surfaces of the waste container, the centre line being located at a height of 700 mm from its lower surface (as shown in Figure 22 in Appendix B2).**
500 L Concrete Drum		**At four positions on the vertical surface of the container lid, spaced at 90°around the circumference (as shown in Figure 24 in Appendix B3 for the 500 L Concrete Drum and in Figure 26 in Appendix B4 for the 1 m^3 Concrete Drum).**
1 m^3 Concrete Drum		
Robust Shielded Waste Packages		
500 L Robust Shielded Drum		**At four positions on the vertical surface, spaced at 90° around the circumference at a height of 1160 mm from the base (as shown in Figure 28 in Appendix C1).**
3 m^3 Robust Shielded Box		**On the centre line of each of the four vertical surfaces of the waste container, at a height of 1345 mm from the base (as shown in Figure 30 in Appendix C2).**

5.5 Handling Features

B14) ***The waste package shall enable safe handling by way of the transport handling systems.***

C113. The transport unit *should* demonstrate compatibility with:

a. Overhead lifting.

b. Restraint on a rail wagon and a road trailer.

B15) ***The waste package shall enable safe handling by way of the GDF handling systems.***

D12. Waste packages *shall* be capable of being lifted as specified in Table 7, without exhibiting any permanent deformation or abnormality that would render them incompatible with the needs for transport or disposal in a GDF.

Table 7 Lifting feature requirements for standard waste package designs.

Waste Container	Lifting Requirements
Unshielded Waste Packages	
500 L Drum	**The waste package *shall* be capable of being lifted with a force equal to twice its gross weight using a standard lifting grab [42].**
3 m^3 Drum	**The waste package *shall* be capable of being lifted with a force equal to twice its gross weight using two diametrically opposite twistlock apertures.**
3 m^3 Box Side Lifting Variant	
3 m^3 Box Corner Lifting Variant	**The waste package *shall* be capable of being lifted with a force equal to twice its gross weight using two diagonally opposite twistlock apertures.**
MBGWS Box	
Shielded Waste Packages	
4 m Box	**The waste package *shall* incorporate corner fittings suitable for its maximum weight to allow lifting, handling and restraint during transport.**
2 m Box	
6 m^3 Concrete Box	
500 L Concrete Drum	**The waste package *shall* be capable of being lifted with a force equal to twice its gross weight.**
1 m^3 Concrete Drum	

Waste Container	Lifting Requirements
Robust Shielded Waste Packages	
500 L Robust Shielded Drum	**The waste package *should* be capable of being lifted with a force equal to twice its gross weight.**
3 m^3 Robust Shielded Box	**The waste package *shall* be capable of being lifted with a force equal to twice its gross weight, using any two diagonally opposite twistlock apertures.**

D13. The handling features of waste packages *shall* be designed to enable compatibility with the transport and GDF handling features, as specified in Table 8.

Table 8 Design requirements for handling features of standard waste package designs.

Waste Container	Handling Feature Design Requirements
Unshielded Waste Packages	
500 L Drum	**The waste container *shall* incorporate a handling feature in the form of a recessed flange, as shown in Appendix D Figure 32.** **The recessed flange *shall* provide access to locate the claws of the lifting grab [42] at any position around the periphery.** **The recessed flange *shall* be located on the top face of the drum.** **The top face of the lid of the waste container *shall* be provided with an annular space clear of any protrusions to allow the feet of the grab to locate correctly on the top of the waste package.** **The annular space *shall* have a maximum inside diameter of 580 mm and be a minimum of 60 mm wide (as marked in red on Figure 9 in Appendix A1).** **The 500 L Drum *shall* be compatible with the standard design of stillage, as defined in WPS/605/01 [21].**
3 m^3 Drum	**The waste container *shall* incorporate four lifting points, in the form of twistlock apertures of dimensions and geometry as defined in Appendix D.** **The lifting features *shall* be located as shown in Appendices A2-A4.** **For the 3 m^3 Drum, the lifting points *shall* be equally spaced.**
3 m^3 Box Side Lifting Variant	
3 m^3 Box Corner Lifting Variant	
MBGWS Box	

Waste Container	Handling Feature Design Requirements
Shielded Box Waste Packages	
4 m Box	**The corner fittings *shall* comprise twistlock apertures of dimensions and geometry as defined in Appendix D.** **The lifting features *shall* be located as shown in Appendices B1-B3.**
2 m Box	
6 m^3 Concrete Box	
500 L Concrete Drum	**The waste package *shall* be capable of being lifted, by way of a standard three-clawed lifting grab, using an integral handling feature, in the form of a recessed channel.** **The handling feature *shall* have the dimensions and geometry defined in Appendix D.** **The handling features *shall* be located as shown in Appendices B4-B5.**
1 m^3 Concrete Drum	
Robust Shielded Waste Packages	
500 L Robust Shielded Drum	**The waste package *should* incorporate a handling feature as described in Appendix D Figure 33.** **The base of the waste container *should* incorporate a lifting feature which complies with that shown in Appendix D.** **The lifting feature *should* be designed to the Standard 1079 produced by the Transport Container Standardisation Committee (TCSC) [43].** **The lifting feature *should* be located as shown in Appendix C1.** **The external features of the waste container *shall* be compatible with the anticipated mode of mounting within the transport container.**
3 m^3 Robust Shielded Box	**The top surface of the waste container *shall* incorporate four lifting points, in the form of twistlock apertures of dimensions and geometry as defined in Appendix D.** **The handling feature *shall* be located as shown in Appendix C2.** **The design of the waste container *shall* enable safe tie-down of the waste package during transport.**

D14. Where the waste package is not disposable in its transport configuration, it *shall* be capable of being removed from its transport configuration using remote handling techniques.

D15. Where a stillage is used, the waste package *shall* be capable of being removed from the stillage using remote handling techniques.

5.6 Durability

B19) ***The waste container shall maintain containment for as long as is required by the GDF safety case.***

C120. The integrity of the waste container, wasteform, and waste package, as a whole, *shall* be maintained for a period of 150 years following manufacture of the waste package.

C121. The integrity of the waste container, wasteform and waste package as a whole, *should* be maintained for a period of 500 years following manufacture of the waste package.

The integrity of the waste package refers to the waste container's handling feature, stacking ability, containment function, the functionality of any engineered vent, as well as maintenance of the external dimension envelope.

D16. For robust shielded waste packages all external surfaces of the waste container *should* be protected with a water impermeable coating.

D17. The integrity of any such coating for robust shielded waste packages *shall* be maintained until the waste package is exported to the GDF.

5.7 Shielding

B29) *The external dose rate from the waste package shall comply with regulatory limits for transport.*

D18. Under the conditions of exclusive use, the external dose rate of the waste package *shall* be such to ensure that the external dose rate of the transport package or overpack does not exceed:

a. 0.1 mSv/hr at 2 m from any external surface; and

b. 2 mSv/hr on any external surface.

The IAEA Transport Regulations [26] apply the first limit to the vehicle. The assumed vehicle designs for the GDF are specified in the Generic Transport System Design (GTSD), DSSC/411/01 [44]. The packages expected to be transported to the GDF will be marginally smaller than the conveyance, and therefore RWM has taken the value of 0.1 mSvhr^{-1} at 2 m as a requirement from the surface of the package.

5.8 Heat Output

5.8.1 At the Time of Transport to a GDF

B32) *The heat generated by the waste package shall be controlled to ensure that regulatory limits on the surface temperature of transport packages are not exceeded.*

D19. The heat generated at the time of transport by the waste package *should* not exceed the values specified in Table 9.

Note, there may be additional heat output restrictions within the contents specifications.

Table 9 Heat output limits, at the time of transport, for the standard waste package designs.

Waste Package	Heat Generated / W
Unshielded Waste Packages	
500 L Drum	100
3 m^3 Box	400
3 m^3 Drum	400
MBGWS Box	400
Shielded Waste Packages	
4 m Box	200
2 m Box	60
6 m^3 Concrete Box	-[1]
500 L Concrete Drum	-[1]
1 m^3 Concrete Drum	-[1]
Robust Shielded Waste Packages	
500 L Robust Shielded Drum	400
3 m^3 Robust Shielded Box in IP-2 transport configuration	-[1]
3 m^3 Robust Shielded Box in Type-B transport configuration	231

[1] *Heat limits are defined in third party contents specification, or are undefined for the transport package. For more information, the reader is directed to contact RWM.*

5.8.2 At the Time of Disposal Vault Backfilling and Closure

B31) ***The heat generated by the waste package shall be controlled to ensure that thermal effects result in no significant deterioration in the performance of the disposal system as a whole.***

C122. The heat output of the waste package at time of disposal vault closure *should* not exceed 6 W/m^3 of conditioned waste.

D20. The heat generated by the waste package at the time of disposal vault backfilling *should* not exceed the values specified in column 1 of Table 10.

It is specifically emphasised for this criterion, that these values are not to be taken as limits and RWM should be consulted to identify where higher values may be justified.

Table 10 Maximum heat outputs at the time of disposal vault backfilling for the standard waste package designs.

Waste Package	Heat Generated / W
Unshielded Waste Packages	
500 L Drum	3
3 m^3 Box	20
3 m^3 Drum	15
MBGWS Box	25
Shielded Waste Packages	
4 m Box	60
2 m Box	35
6 m^3 Concrete Box	30
500 L Concrete Drum	3
1 m^3 Concrete Drum	5
Robust Shielded Waste Packages	
500 L Robust Shielded Drum	3
3 m^3 Robust Shielded Box	18

5.9 Surface Contamination

B33) ***The non-fixed surface contamination of the waste package shall be as low as reasonably practicable (ALARP).***

B41) ***The non-fixed surface contamination of the waste package shall comply with regulatory limits during transport.***

To ensure that the non-fixed contamination of the waste package is within IAEA regulatory limits for transport:

C123. For transport packages in their own right the non-fixed surface contamination, when averaged over an area of 300 cm^2 of any part of the surface of the waste package, shall not exceed:

a. 4.0 Bq cm^{-2} for beta, gamma and low toxicity alpha emitters.

b. 0.4 Bq cm^{-2} for all other alpha emitters.

C124. For waste packages transported inside transport containers, the non-fixed surface contamination, when averaged over an area of 300 cm^2 of any part of the surface of the waste package, should not exceed:

a. 4.0 Bq cm^{-2} for beta, gamma and low toxicity alpha emitters.

b. 0.4 Bq cm^{-2} for all other alpha emitters.

5.10 Voidage

C125 The development and production of the waste package *shall* ensure that the volume of voidage within the waste package is minimised.

5.11 Gas Generation

All specified gas generation rates in the following sections are for volumes of gas at standard temperature and pressure (i.e. 0°C and 101 kPa).

5.11.1 Waste Package Design

D21. For waste packages transported within transport containers or an overpack, the waste package *shall* be designed to prevent the formation of a flammable atmosphere in the cavity between the waste package and transport container.

D22. For waste packages transported within transport containers or an overpack, the release of gas from the waste package *should* not exceed 50% of the lower flammability limit for any gases generated.

It is assumed that the cavity of the SWTC and RSBTC will be purged with nitrogen which prevents the formation of such an atmosphere during transport.

5.11.1.1 Waste Packages with Vents

C128. Any vents incorporated into the design of a waste container *shall*:

a. Minimise the release of particulate materials.

b. Allow the controlled release of gas to ensure compliance with the Pressure Systems Safety Regulations (PSSR).

c. Be situated so that they do not become blocked when packages are handled or stored.

5.11.1.2 Permeable Containers

D23. The walls of the waste container *shall* be sufficiently permeable such that gases generated by the wasteform do not damage the integrity of the waste package.

5.11.2 Gas Generation and Pressurisation During Transport

B35) ***The generation of bulk, radioactive and toxic gases by the waste package shall comply with the requirements for safe transport.***

B37) ***The release of radionuclides in gaseous form from the waste package shall comply with the assumptions that underpin the safety cases for transport.***

The following requirement is derived from the IAEA Transport Regulations Para 664.

C27. The maximum normal operating pressure of a transport package *shall* not exceed a gauge pressure of 700 kPa for Type B(U) transport packages.

Limits are provided below for gas generation and the release of activity for each waste package in the anticipated transport configuration. The derivation of the values in this section can be found in the contents specification, which may also impose additional limits (See Table 2 for references).

D24. For waste packages transported as part of a Type B transport package, the total gas generated and released from the waste package during transport *shall* not exceed the values specified in Table 11.

Table 11 Limits for the release of gas from the standard waste package designs for containers transported as part of a Type B transport package during transport.

Waste Package		Gas Release / L/day
Unshielded Waste Packages		
500 L Drum		64
3 m^3 Drum		220
3 m^3 Box	Side Lifting Variant	90
	Corner Lifting Variant	66
MBGWS Box		84
Robust Shielded Waste Packages		
500 L Robust Shielded Drum		700
3 m^3 Robust Shielded Box		32

D25. For waste packages transported as part of a Type B transport package, the release of activity, in gaseous and particulate form, from the waste package during transport *shall* not exceed the values specified in Table 12.

Table 12 Activity release limits from the standard waste package designs for containers transported as/as part of a Type B transport package.

Waste Package	Activity Release / 10^{-04} A_2/day
Unshielded Waste Packages	

500 L Drum		4.7
3 m^3 Drum		16
3 m^3 Box	Side Lifting Variant	6.6
	Corner Lifting Variant	4.7
MBGWS Box		6.1
Robust Shielded Waste Packages		
500 L Robust Shielded Drum		43
3 m^3 Robust Shielded box		1.5 [1]

[1] *Currently this number accounts for gaseous release within the cavity of the RSBTC only, future work is planned to include the contribution of particulate release within the contents specification.*

D26. Type IP-2 transport packages or waste packages transported as part of a Type IP-2 transport package *shall* prevent the loss or dispersal of the radioactive contents.

5.11.3 Gas Generation During the GDF Operational Period

B36) ***The generation of bulk, radioactive and toxic gases by the waste package shall comply with the requirements for disposal.***

B38) ***The release of radionuclides in gaseous form from the waste package shall comply with the assumptions that underpin the safety cases for the GDF operational period.***

5.12 Accident Performance

B43) ***Under all credible accident scenarios the release of radionuclides and other hazardous materials from the waste package shall be low.***

B44) ***Under all credible accident scenarios the release of radionuclides and other hazardous materials from the waste package shall be predictable.***

B45) ***The waste package should exhibit progressive release behaviour within the range of all credible accident scenarios.***

5.12.1 Transport Testing and Performance Requirements

Test Conditions for Routine Conditions of Transport (RCT), Normal Conditions of Transport (NCT), and Accident Conditions of Transport (ACT), are specified in the Part C Specification [1].

5.12.2 Operations

B49) ***The accident performance of the waste package shall ensure that, in the event of any credible accident during the GDF operational period, the on- and off-site***

doses resulting from the release of radionuclides from the waste package should be consistent with meeting the relevant Basic Safety Levels.

C37. A waste package *shall* minimise the loss of containment in the event of a reference accident scenario.

C38. A waste package *should* be designed to minimise the loss of integral shielding in the event of a reference accident scenario.

Table 15 below is included within the Part C Specification [1] (WPS/220/01) and encompasses reference accident scenarios. However, it has been repeated here as these scenarios are specific to the waste package type. The reader is encouraged to see Section 4, Operational Phase, of the Part C Specification.

Table 13 Design basis accident scenarios for the standard waste package designs.

Reference Accident Scenario	Package Type	Conditions	Reference
Fire (°C and minutes)	Unshielded	1000 °C in a fully engulfing fire for a duration of 30 minutes.	[45]
	Shielded	1000 °C in a fully engulfing fire for a duration of 60 minutes.	
	Robust Shielded	1000 °C in a fully engulfing fire for a duration of 60 minutes.	
Drop height (m)	Unshielded	11 m onto a flat unyielding target. 10 m onto an aggressive target (e.g. another waste package)	[46]
	Shielded	10 m onto a flat unyielding target. No limit has currently been defined for an aggressive feature.	
	Robust Shielded	7.5 m onto a flat unyielding target. 6 m onto an aggressive feature.	

Appendix A – Unshielded Waste Package Datasheets

Appendix A1 – 500 L Drum

Description

A number of variants of the 500 L Drum have been developed by various site licensed companies for use in the packaging of specific waste types. These fit within the standard dimensional envelope and have been developed to accommodate the process requirements for conditioning a wide range of wastes.

To permit the safe handling and stacking of 500 L Drum waste packages during their lifecycle (including transport and disposal), 'stillages' containing a 2 x 2 array of waste packages (Drums) will be used.

Waste

Utilised for the packaging of waste with a wide range of physical, chemical, and radiological properties. The wastes packaged within this waste container can be used with or without an immobilising medium, which is dependent upon the properties of the waste.

Transport

It is envisaged that four 500 L Drum waste packages will be placed within a stillage and transported through the public domain inside a SWTC. The combination of waste packages, stillage, and transport container will form a Type B transport package.

Transport of the stillage within the SWTC-285 has been assumed to determine the limits within this specification.

Figure 8 Rendering of the 500 L Drum waste container.

Summary of Key Features

Maximum external dimensions / mm 800 (Diameter), 1230 (Height)	**Typical drum aperture size / mm** Ø 730
Internal payload volume / m^3 0.47	**Typical material of construction** Stainless steel
Typical thickness / mm 3 (Wall), 3 (Base)	**Stacking requirement** Capable of withstanding a compressive load of 12 t applied along the vertical axis of the waste package
Typical empty container mass / t 0.13	**Lifting feature** Drum body/lid flange of defined shape
Maximum waste package mass / t 2.0	

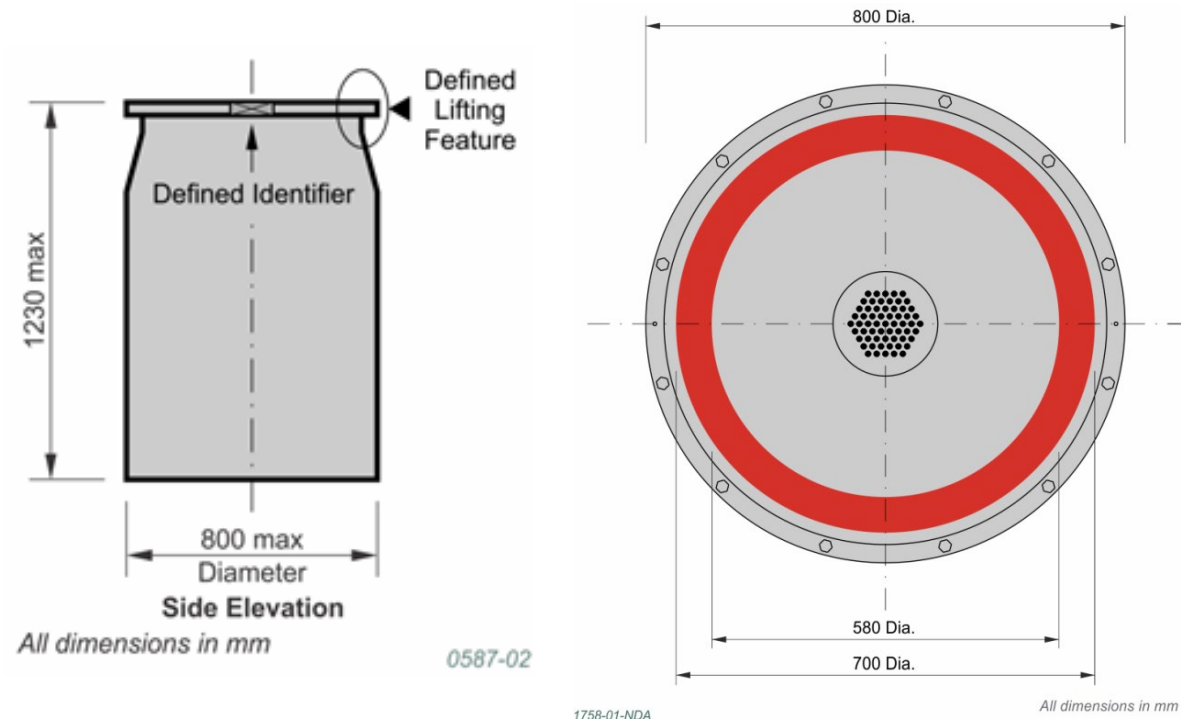

Figure 9 Schematic of the standard features of the 500 L Drum (left), and the required clear area (shown in red) on the lid of the 500 L Drum waste container (right).

Appendix A2 – 3 m^3 Drum

Description
Manufactured from stainless steel with a typical containment thickness of ~ 3 mm. This waste package was developed for the bulk packaging of wet wastes and can be used as an alternative to the 500 L Drum.
Waste
Intended for packaging a range of liquid, sludge and slurry wastes. These wastes are typically conditioned through a process of 'in-drum mixing' of the waste with an immobilising material.
Transport
It is envisaged that one 3 m^3 Drum waste package will be transported through the public domain inside a SWTC. The combination of waste package and transport container will constitute a Type B transport package.

Transport within the SWTC-285 has been assumed to determine the limits within this specification.

Figure 10 Rendering of the standard 3m^3 Drum waste container.

Summary of Key Features

Maximum external dimensions / mm 1720 (Diameter), 1245 (Height)	**Typical drum aperture size / mm** Ø 765
Internal payload volume / m^3 2.6	**Typical material of construction** Stainless steel
Typical thickness / mm 3	**Stacking requirement** Capable of withstanding a compressive load of 48 t applied along the vertical axis of the waste package
Typical empty container mass / t 0.7	**Lifting feature** Four twistlock apertures located on the top surface of the container
Maximum waste package mass / t 8	

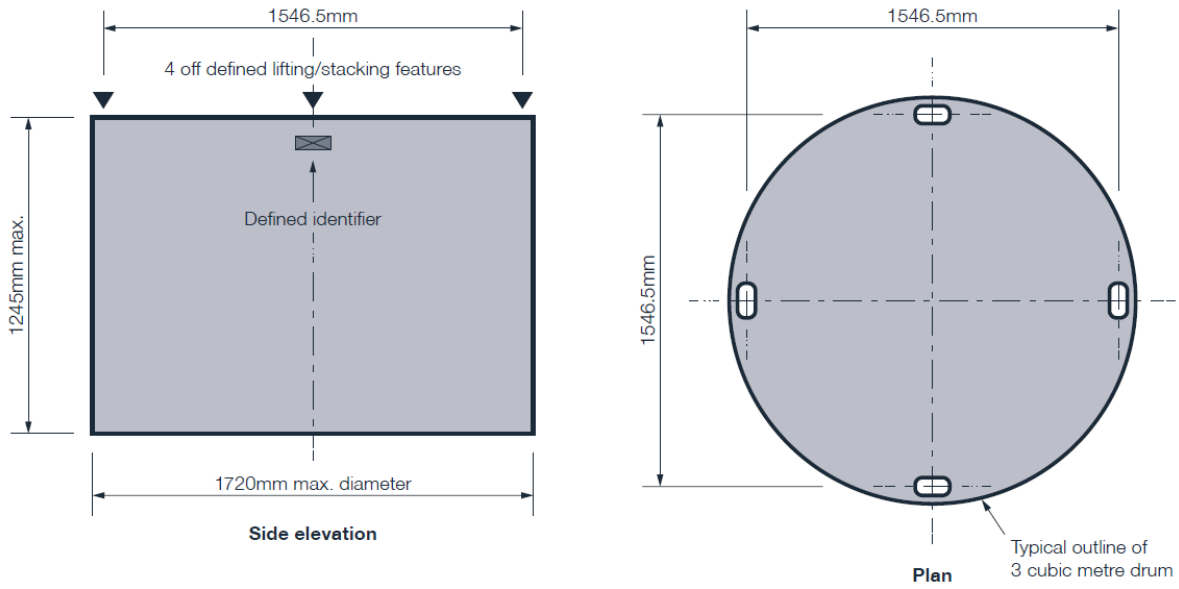

Figure 11 Schematic of the standard features of the 3 m^3 Drum (left), and layout of the lifting features (right).

Appendix A3 – 3 m^3 Box (Side lifting and Corner lifting variants)

Description

The 3 m^3 Box is a cuboidal waste container typically used for the conditioning of solid wastes. Within the standard dimensional envelope defined for the 3 m^3 Box, two distinct variants have been developed to accommodate the process requirements for packaging wastes at different sites. The two variants are distinguished by their lifting features, which are located at the mid points of the sides of the container (the 'side-lifting' variant), or at the corners of the container (the 'corner-lifting' variant).

Waste

It is intended to be used in the packaging of a range of heterogeneous wastes conditioned by infilling the waste in the container with an immobilising medium. The possibility to package certain types of waste without the use of an immobilising medium exists when using this waste container.

Transport

It is envisaged that a single 3 m^3 Box waste package will be transported through the public domain inside a SWTC. The combination of waste package and transport container will together constitute a Type B transport package.

Transport within the SWTC-285 has been assumed to determine the limits within this specification.

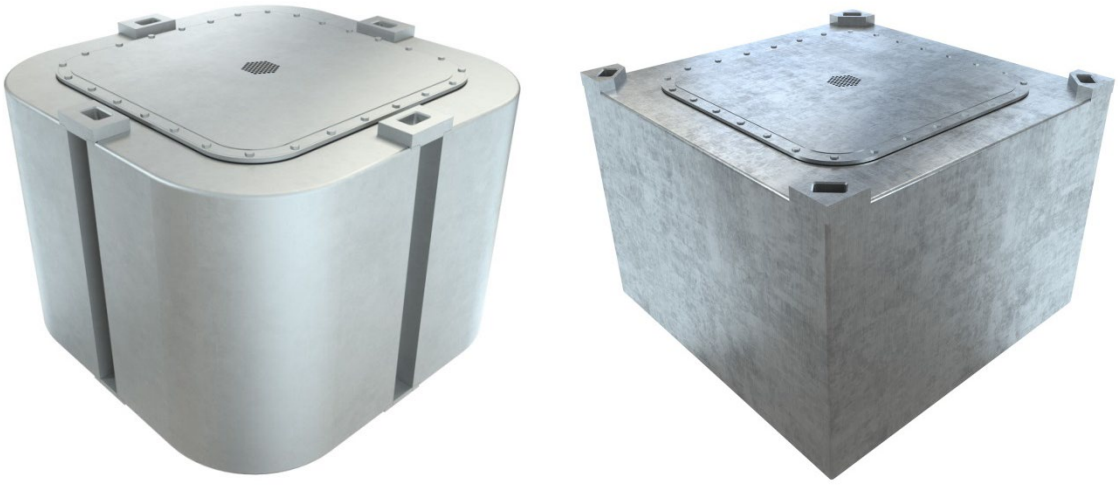

Figure 12 Rendering of the variants of the 3 m^3 Box waste container. The side lifting variant is depicted on the left, while the corner lifting variant is illustrated on the right.

Summary of Key Features

Maximum external dimensions / mm 1720 (Length), 1720 (Width), 1245 (Height)	**Typical aperture size / mm** Side Lifting Variant: 1214 sq. (internal corner radius: 180) Corner Lifting Variant: 1499 sq. (internal corner radius: 544)
Internal payload volume / m^3 2.75	
Typical thickness / mm 6	**Typical material of construction** Stainless steel
Typical empty container mass / t 0.8	**Stacking requirement** Capable of withstanding a compressive load of 72 t applied along the vertical axis of the waste package
Maximum waste package mass / t 12	**Lifting feature** Four twistlock apertures located on the top surface of the container

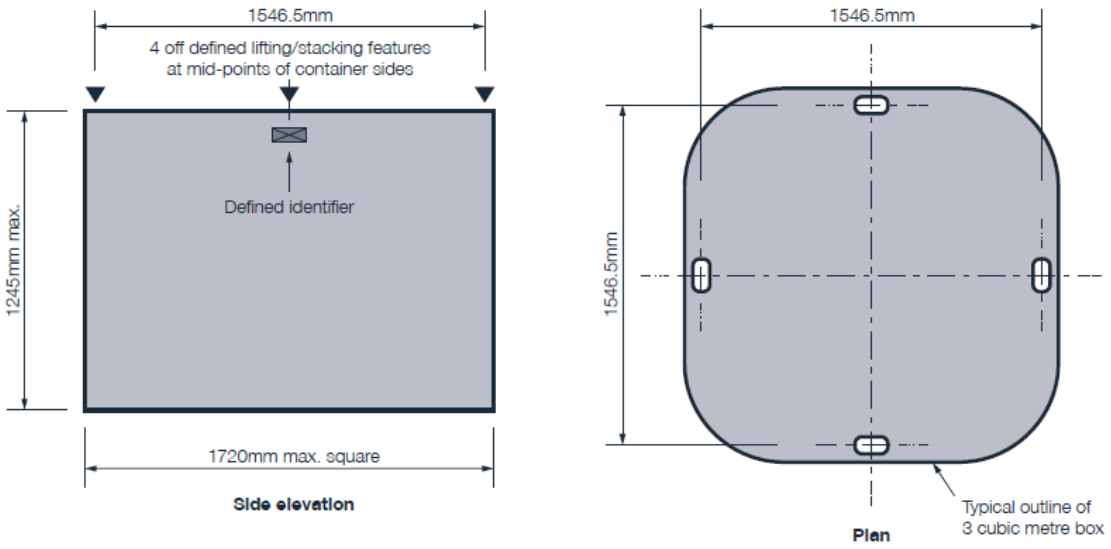

Figure 13 Schematic of the standard features of the 3 m^3 Box side lifting variant (left), and layout of the lifting features (right).

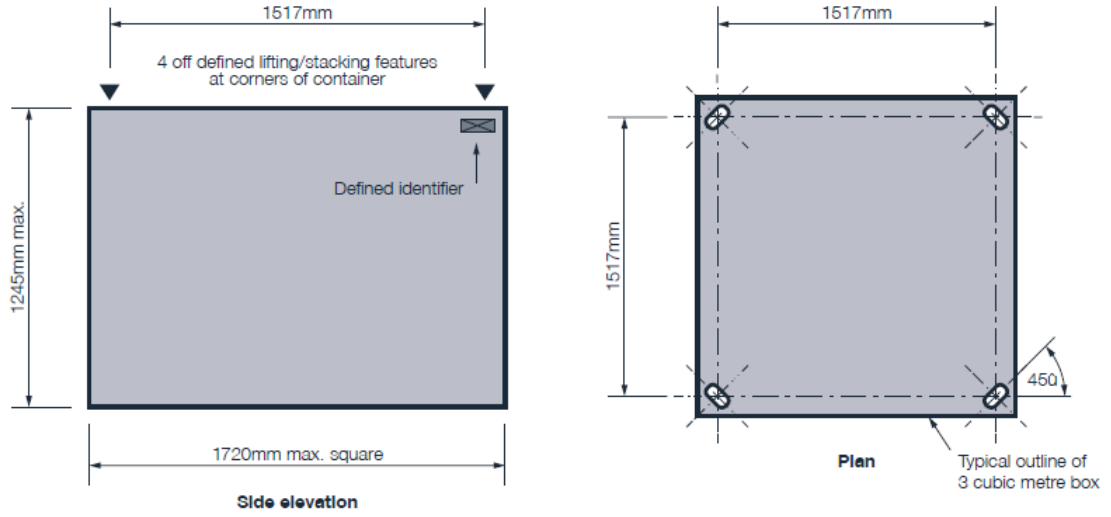

Figure 14 Schematic of the standard features of the 3 m^3 Box Corner Lifting Variant (left), and layout representation of the lifting features (right).

Appendix A4 – Miscellaneous Beta Gamma Waste Store (MBGWS) Box

Description

The Miscellaneous Beta Gamma Waste Store (MBGWS) Box is a cuboidal waste container developed for the temporary storage of a range of wastes arising from operations at Sellafield. It is currently anticipated that, prior to export to a GDF, the waste currently held in MBGWS boxes will be further conditioned to produce disposable waste packages.

Waste

Can be used in the packaging of heterogeneous wastes, which would typically be conditioned by infilling the waste in the container with an immobilising material. There additionally exists the potential for the MBGWS box to be used for the packaging of certain types of waste without the inclusion of an immobilising medium.

Transport

It is envisaged that one MBGWS Box waste package will be transported through the public domain inside a SWTC. The combination of waste package and transport container will constitute a Type B transport package.

Transport inside the SWTC-150 has been assumed to determine the limits within this specification.

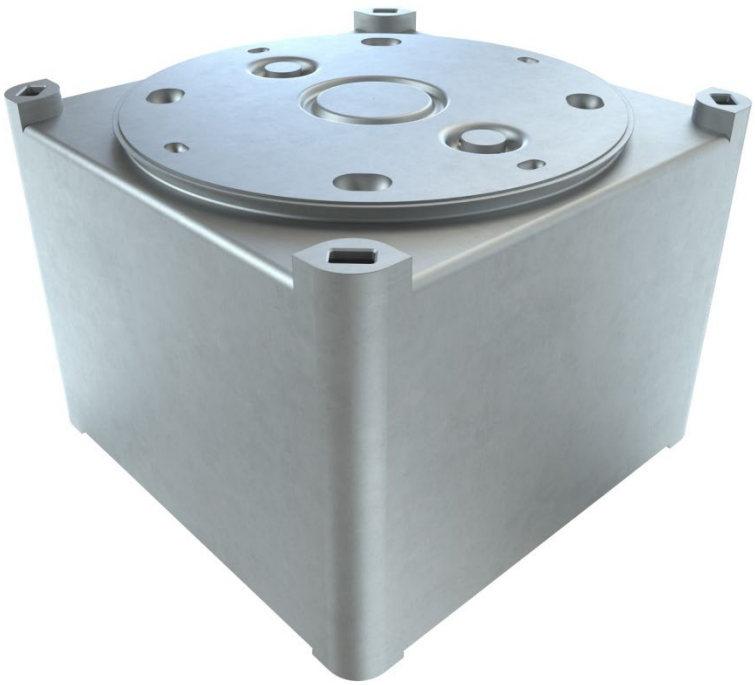

Figure 15 Rendering of a Miscellaneous Beta Gamma Waste Store (MBGWS) Box waste container.

Summary of Key Features

Maximum external dimensions / mm 1853 (Length), 1853 (Width), 1372 (Height)	**Typical aperture size / mm** Ø 1648
Internal payload volume / m^3 3.5	**Typical material of construction** Mild or Stainless steel
Typical thickness / mm 10	**Stacking requirement** Capable of withstanding a compressive load of 60 t applied along the vertical axis of the waste package
Typical empty container mass / t 1.3 – 2.8	**Lifting feature** Four twistlock apertures located on the top surface of the container
Maximum waste package mass / t 12	

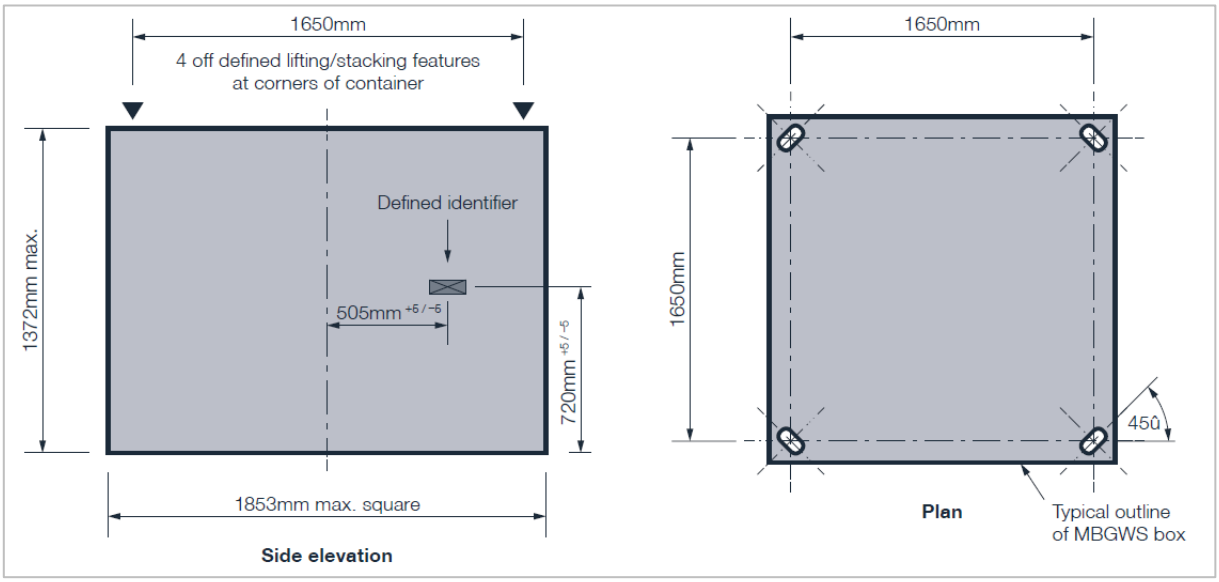

Figure 16 Schematic of the standard features of the MBGWS Box (left), and layout of the lifting features (right).

Appendix B – Shielded Waste Package Datasheets

Appendix B1 – 4 m Box

Description
The 4 m Box is a large waste container intended to be used predominantly for large waste items arising from the decommissioning of nuclear facilities. The key external dimensions of the 4 m Box are based on the principles established for Series 1 International Organisation for Standardisation (ISO) freight containers.
Waste
These large waste items arising from the decommissioning of nuclear facilities may be conditioning using an immobilising medium, although the possibility also exists for wastes to be packaged without an immobilising medium.
Transport
4 m Box waste packages qualify as Type IP-2 transport packages in their own right, and will be transported through the public domain without the need for additional protection. *It is assumed that the 4 m box will qualify as a transport package in its own right and will be a Type IP-2 transport package.*

Figure 17 Rendering of a 4 m Box waste container.

Summary of Key Features

Maximum external dimensions / mm 4013 (Length), 2438 (Width), 2200 (Height)	**Typical aperture size / mm** 3310 x 1738
Internal payload volume* / m^3 8.1 – 18.9	**Typical material of construction** Stainless steel (optional concrete liner for shielding)
Typical thickness / mm 3	**Stacking requirement** Capable of withstanding a compressive load of 260 t applied along the vertical axis of the waste package
Typical empty container mass* / t 5 – 31	
Maximum waste package mass / t 65	**Lifting feature** Four twistlock apertures located on the top surface of the container
Shielding thickness available / mm 0 – 300	

**Dependent on shielding thickness*

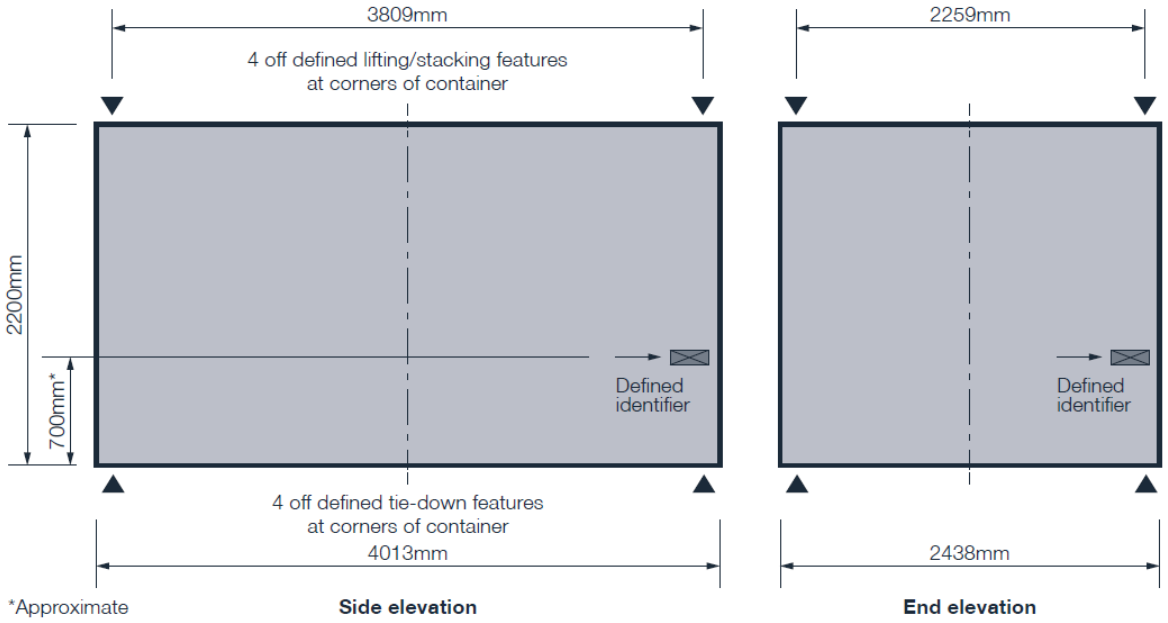

Figure 18 Schematic of the standard features of the 4 m Box.

Appendix B2 – 2 m Box

Description
The 2 m Box is a waste container intended to be used predominantly for waste items arising from the decommissioning of nuclear facilities. The waste container is effectively a half-length variant of the 4 m Box and is designed for use where space at the packaging plant is more limited, or where the option for rail transport does not exist.
Waste
The 2 m Box can be used to package waste with or without an immobilising medium.
Transport
2m Box waste packages qualify as Type IP-2 transport packages in their own right and will be transported through the public domain without the need for additional protection.

It is assumed that the 2 m Box will qualify as a transport package in its own right and will be a Type IP-2 transport package.

Figure 19 Rendering of the 2 m Box waste container.

Summary of Key Features

Maximum external dimensions / mm 1969 (Length), 2438 (Width), 2200 (Height)	**Typical aperture size / mm** 2142 x 1673 (corner chamfer 200 sq.)
Internal payload volume* / m^3 5.0 - 9.5	**Typical material of construction** Stainless steel (optional concrete liner for shielding)
Typical thickness / mm 6	**Stacking requirement** Capable of withstanding a compressive load of 160 t applied along the vertical axis of the waste package
Typical empty container mass* / t 3 – 15	**Lifting feature** Four twistlock apertures located on the top surface of the container
Maximum waste package mass / t 40	
Shielding thickness available / mm 0 – 200	

**Dependent on shielding thickness*

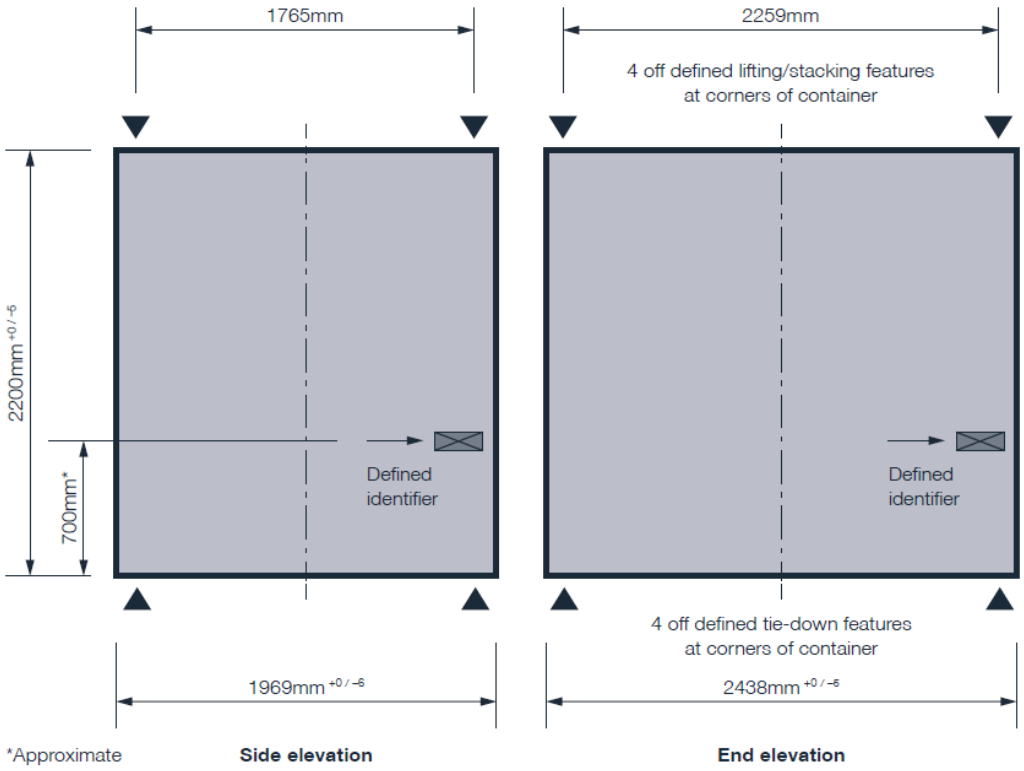

Figure 20 Schematic of the standard features of the 2 m Box.

Appendix B3 – 6 m^3 Concrete Box

Description
The 6 m^3 Box can be manufactured to incorporate high-density materials (e.g. haematite) to maximise its radiation shielding properties. This container is reinforced using steel re-bar. The walls of the container, being gas permeable, allow the release of internally generated gases and therefore the waste container may not require the incorporation of a specific engineered vent.
Waste
Used for the packaging of a range of heterogeneous wastes which are placed into the container and encapsulated through the application of a cementitious grout. After conditioning of the waste, the waste package is finalised through the *in-situ* casting of an upper grout capping surface.
Transport
6 m^3 Concrete Box waste packages satisfy the requirement to be transported as Type IP-2 transport packages in their own right, and will therefore be transported through the public domain without the need for additional protection. *It is assumed that the 6 m^3 Concrete Box will qualify as a transport package in its own right and will be a Type IP-2 transport package.*

Figure 21 Rendering of a 6 m^3 Concrete Box.

Summary of Key Features

Maximum external dimensions / mm 2210 (Length), 2438 (Width), 2200 (Height)	**Typical aperture size / mm** 1630 x1858
Internal payload volume / m^3 5.8	**Typical material of construction** Concrete
Typical thickness / mm ~240	**Stacking requirement** Capable of withstanding a compressive load of 200 t applied along the vertical axis of the waste package
Typical empty container mass / t 26	**Lifting feature** Four twistlock apertures located on the top surface of the container
Maximum waste package mass / t 50	
Shielding thickness available / mm ~ 240	

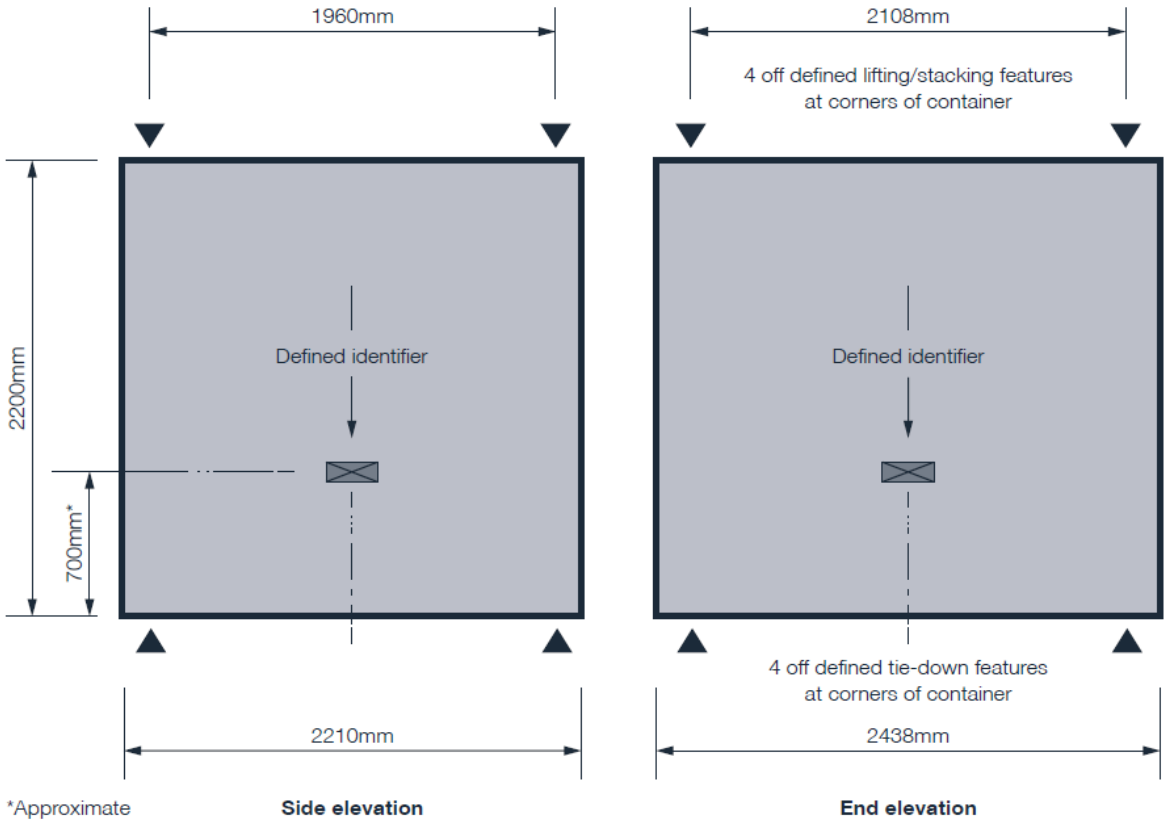

Figure 22 Schematic of the standard features of the 6 m^3 Concrete Box.

Appendix B4 – 500 L Concrete Drum

Description
The 500 L Concrete Drum is manufactured from concrete with a thickness of ~ 160 mm. Further radiation shielding can be provided by the addition of an internal steel liner within the base and walls of the container. The lid of the container, being gas permeable, allows for the release of internally generated gases. Therefore, the waste container does not require the addition of an engineered vent.
Waste
Primarily intended for the packaging of wastes which have been encapsulated with a cementitious grout. After conditioning of the waste in this way, the waste package is completed by the *in situ* casting of an upper (capping) surface.
Transport
500 L Concrete Drum waste packages satisfy the requirements for transport as Type IP-2 transport packages in their own right, and will be transported through the public domain without the need for additional protection. *It is assumed that the 500 L Concrete Drum will qualify as a transport package in its own right and will be a Type IP-2 transport package.*

Figure 23 Rendering of a 500 L Concrete Drum Waste Container.

Summary of Key Features

Maximum external dimensions / mm 1102 (Diameter), 1302 (Height)	**Typical drum aperture size / mm** Ø 780
Internal payload volume / m^3 0.3 - 0.5	**Typical material of construction** Concrete
Typical thickness / mm 160	**Stacking requirement** Capable of withstanding a compressive load of 36 t applied along the vertical axis of the waste package
Typical empty container mass / t 1.9 – 2.7	**Lifting feature** Drum body recessed channel of defined shape
Maximum waste package mass / t 6	

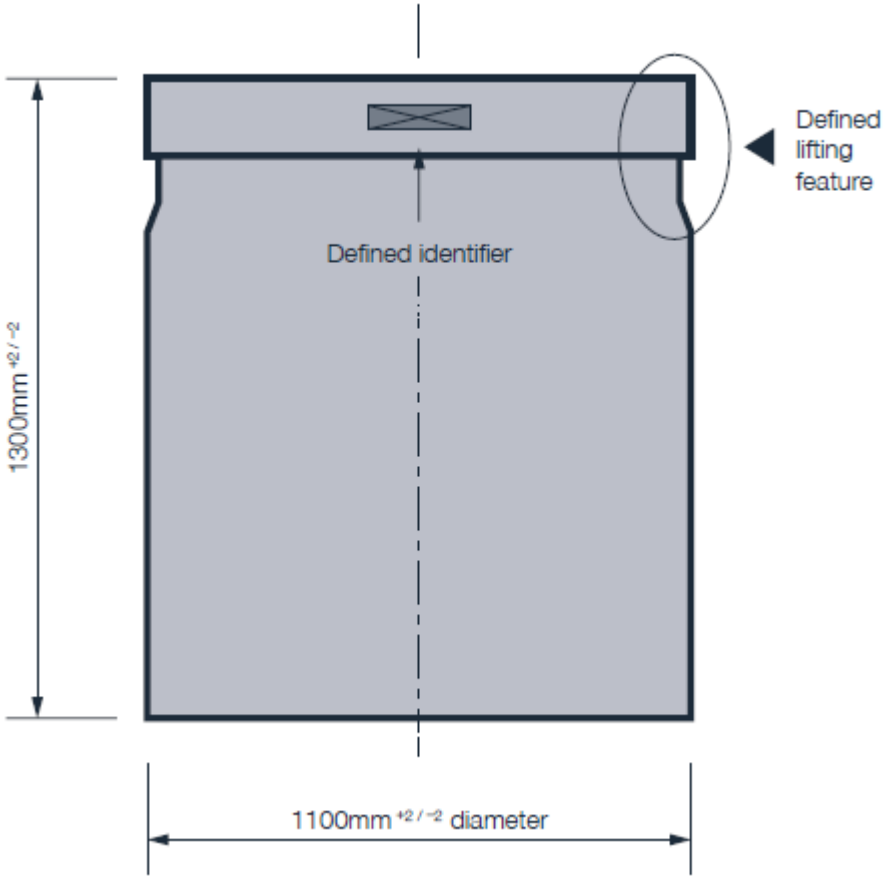

Figure 24 Schematic of the standard features of the 500 L Concrete Drum.

Appendix B5 – 1 m^3 Concrete Drum

Description
The 1 m^3 Concrete Drum is manufactured from reinforced concrete of thickness ~160 mm, with additional radiation shielding being provided (if required) through the addition of an internal steel liner on the base and walls of the container. The lid of the container, being gas permeable, allows for the release of internally generated gases and, therefore, the waste container does not require the incorporation of an engineered vent.
Waste
Used for the packaging of a range of heterogeneous wastes which are placed into the container and encapsulated with a cementitious grout. After conditioning of the waste, the waste package is completed by the *in situ* casting of an upper (capping) surface.
Transport
1 m^3 Concrete Box waste packages satisfy the requirements to be transported as Type IP-2 transport packages in their own right and will be transported through the public domain without the need for additional protection. *It is assumed that the 1 m^3 Concrete Drum will qualify as a transport package in its own right and will be a Type IP-2 transport package.*

Figure 25 Rendering of a 1 m^3 Concrete Drum Waste Container.

Summary of Key Features

Maximum external dimensions / mm 1402 (Diameter), 1302 (Height)	**Typical drum aperture size / mm** Ø 1080
Internal payload volume / m^3 0.5 – 0.9	**Typical material of construction** Concrete
Typical thickness / mm 160	**Stacking requirement** Capable of withstanding a compressive load of 48 t applied along the vertical axis of the waste package
Typical empty container mass / t 2.6 – 4.9	**Lifting feature** Drum body recessed channel of defined shape
Maximum waste package mass / t 8	

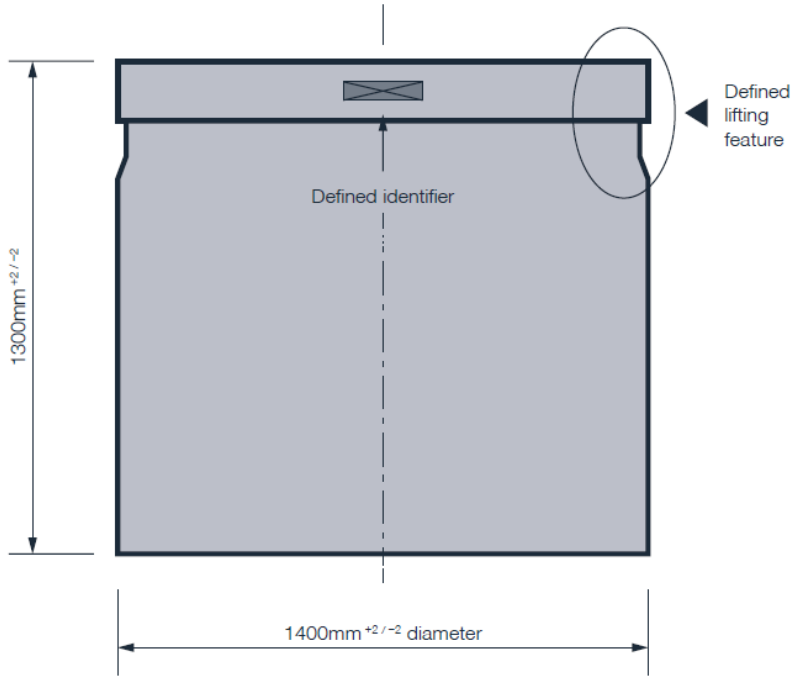

Figure 26 Schematic of the standard features of the 1 m^3 Concrete Drum.

Appendix C – Robust Shielded Waste Package Datasheets

Appendix C1 – 500 L Robust Shielded Drum

Description
The 500 L Robust Shielded Drum is a waste container manufactured from ductile cast iron with a range of wall thicknesses. Therefore, the required performance of the overall waste package is placed largely on the performance of the waste container.
Waste
Suitable for the conditioning of waste with or without an encapsulating medium.
Transport
It is the current assumption that a waste package produced using the 500 L Robust Shielded Drum waste container will be placed within a stillage and transported through the public domain inside a SWTC, specifically the SWTC-150. *The 500 L Robust Shielded Drum will be placed into a stillage, which in turn will be transported within the 150 mm design of SWTC. The SWTC will qualify as a Type B transport package.*

Figure 27 Rendering of a 500 L Robust Shielded Drum Waste Container.

Summary of Key Features

Maximum external dimensions / mm 1070 (Diameter), 1520 (Height)	**Typical drum aperture size / mm** Ø 730
Internal payload volume* / m^3 0.1 – 0.4	**Typical material of construction** Ductile cast iron
Typical thickness / mm 160	**Stacking requirement** Capable of withstanding a compressive load of 40 t applied along the vertical axis of the waste package
Typical empty container mass* / t 5.7 – 9.2	**Lifting feature** Recess located at the base of the drum
Maximum waste package mass / t 10	

**Dependent upon thickness of the liner.*

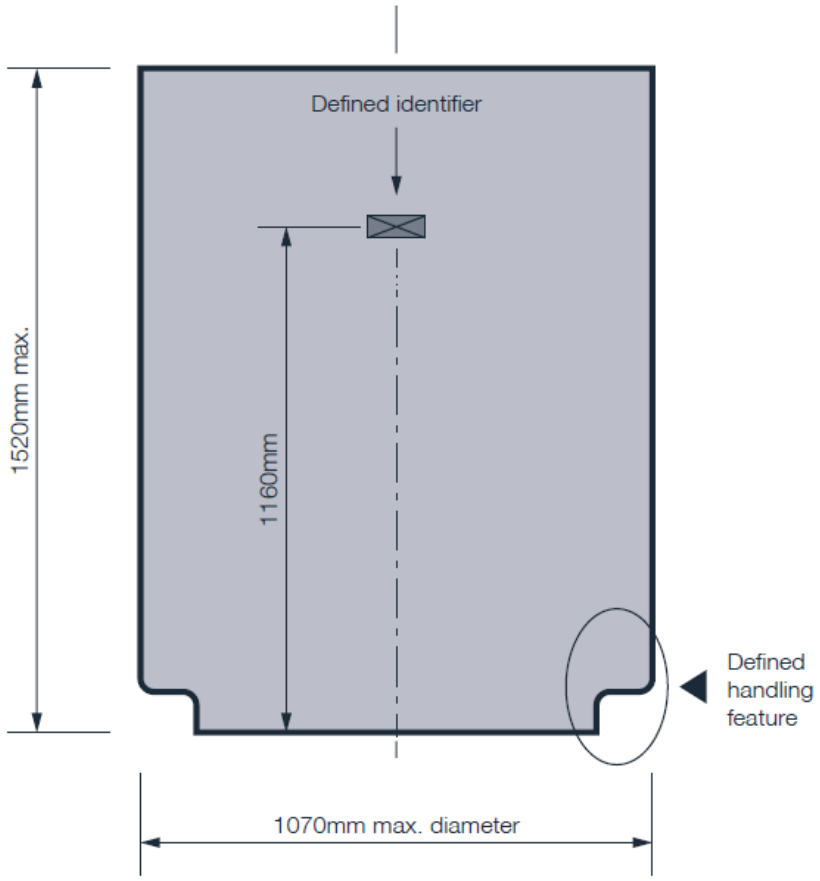

Figure 28 Rendering of the standard features of the 500 L Robust Shielded Drum.

Appendix C2 – 3 m^3 Robust Shielded Box

Description
The 3 m^3 Robust Shielded Box is typically manufactured from ductile cast iron, typically with a wall thickness of 160 mm. Therefore, the required performance of the waste package is largely placed on the performance of the waste container.
Waste
Potentially suitable for the conditioning of waste with or without an immobilising medium.
Transport
It is the current assumption that waste packages manufactured using the 3 m^3 Robust Shielded Box waste container will be transported through the public domain either in a Type B or Type IP-2 transport configuration. • For Type B transport configuration, it is anticipated that the waste package will be transported within an RSBTC. • In a Type IP-2 arrangement, it is anticipated that the waste package will be transported within an ISO freight container rated to IP-2 standard. Such an ISO freight container may act as a transport container, forming part of the transport package (in which the transport package will satisfy the requirement to be transported as a Type IP-2 transport package), or act as an overpack (in which the waste package satisfies the requirements of a Type IP-2 package). The role of the ISO freight container ought to be determined prior to the application of the requirements as detailed within this specification.

Figure 29 Rendering of 3 m^3 Robust Shielded Box waste container.

Summary of Key Features

Maximum external dimensions / mm 2010 (Length), 1610 (Width), 1740 (Height)	**Typical aperture size / mm** Ø 730
Internal payload volume / m^3 2.5	**Typical material of construction** Ductile cast iron
Typical thickness / mm 160	**Stacking requirement** Capable of withstanding a compressive load of 100 t applied along the vertical axis of the waste package
Typical empty container mass / t 18.3	**Lifting feature**
Maximum waste package mass / t 25	Four twistlock apertures located on the top surface of the container

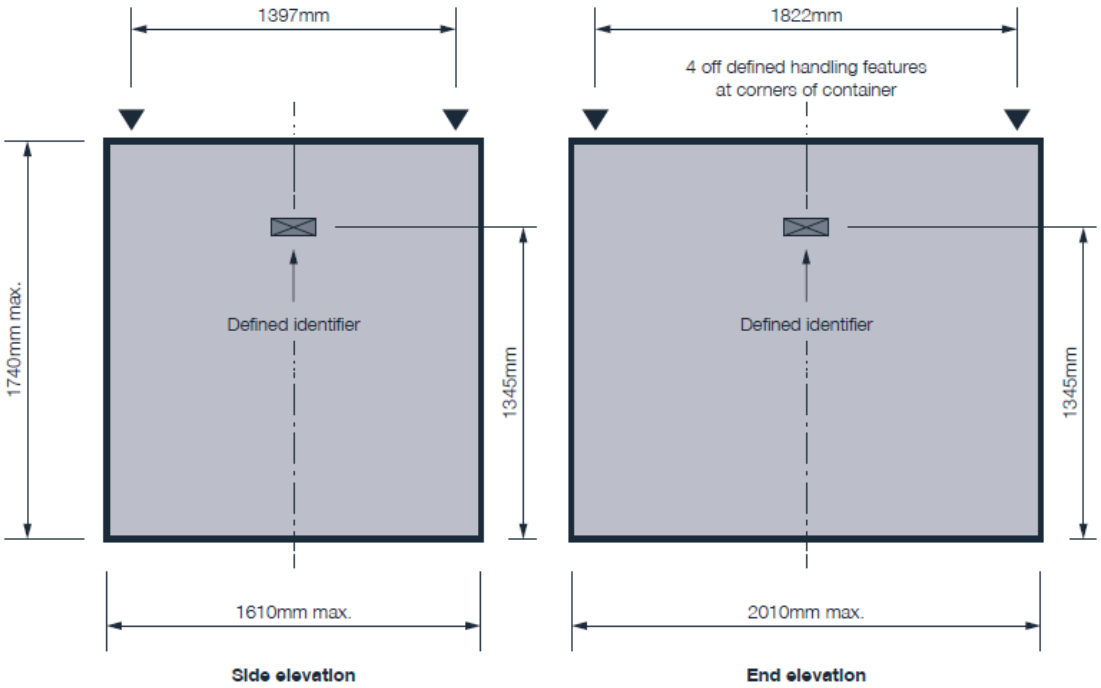

Figure 30 Schematic of the standard features of the 3 m^3 Robust Shielded Box.

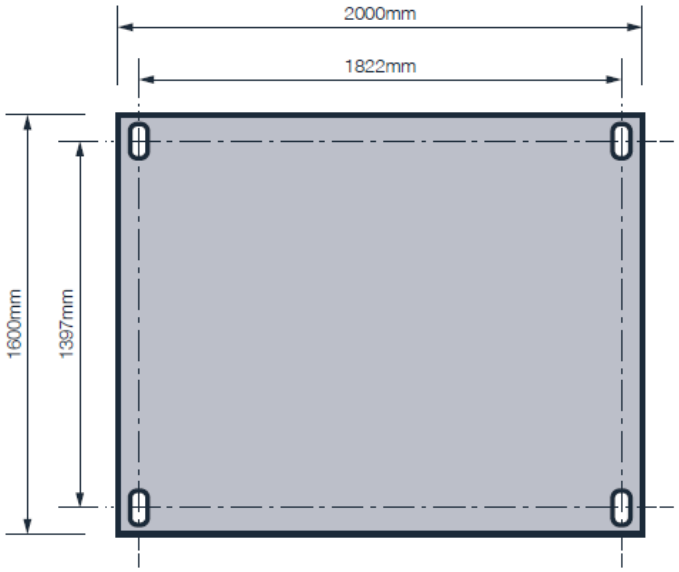

Figure 31 Layout schematic of the lifting features for the 3 m^3 Robust Shielded Box.

Appendix D – Waste Package Handling Features

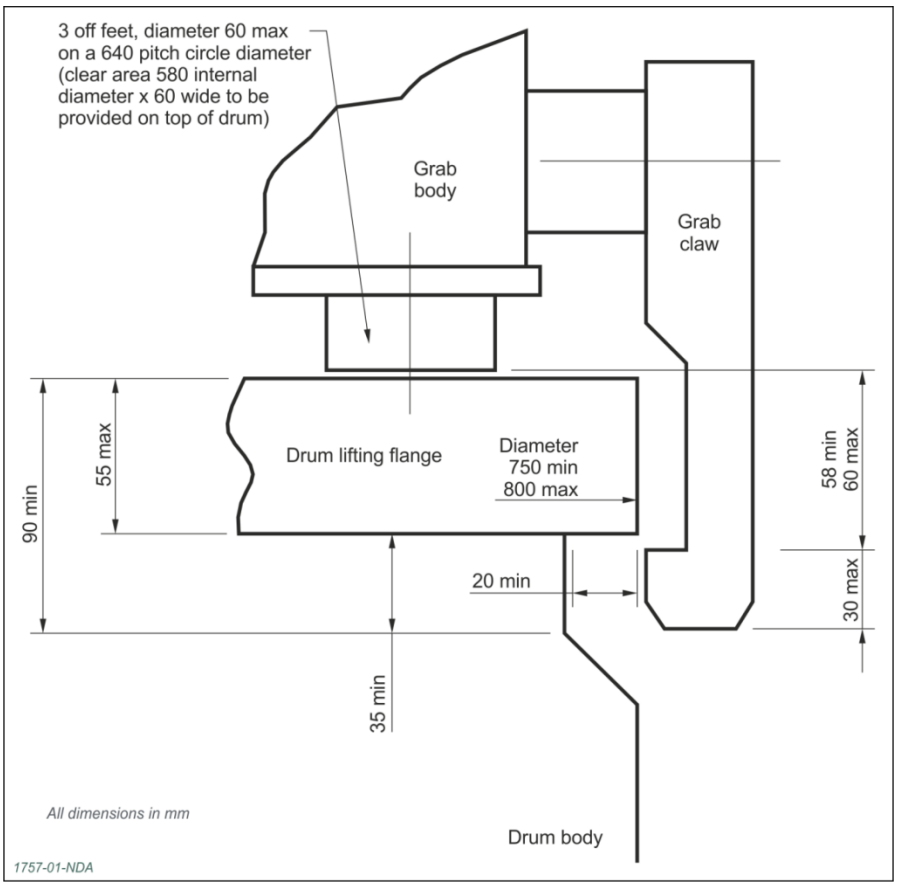

Figure 32 Schematic of the lifting feature of the 500 L Drum.

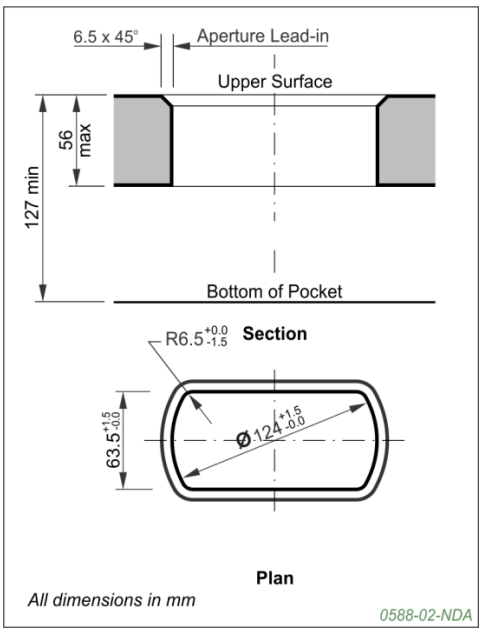

Figure 33 Schematic of the twistlock geometry and dimensions for the 3 m³ Drum, 3 m³ Box Side Lifting Variant, 4 m Box, 2 m Box, 6 m³ Concrete Box, and 3 m³ Robust Shielded Box.

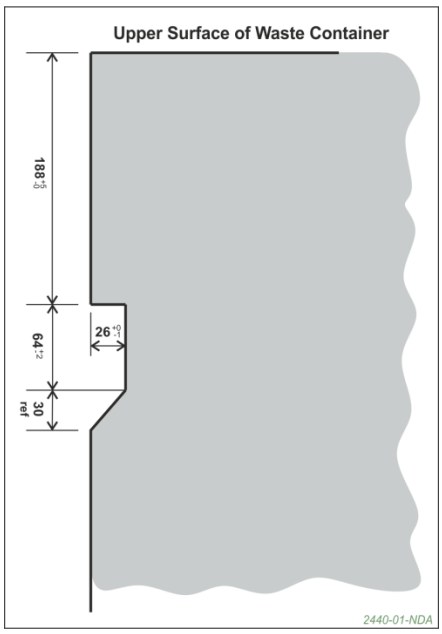

Figure 34 Schematic of the handling features of the 500 L Concrete Drum and 1 m³ Concrete Drum.

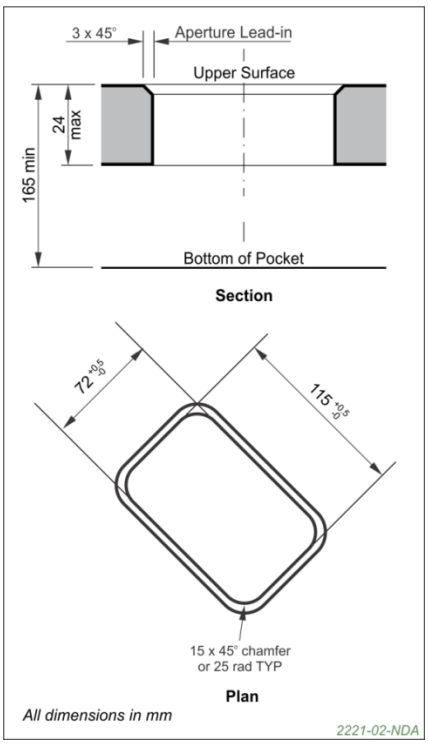

Figure 35 Schematic of the twistlock geometry and dimensions for the 3 m^3 Box Corner Lifting Variant.

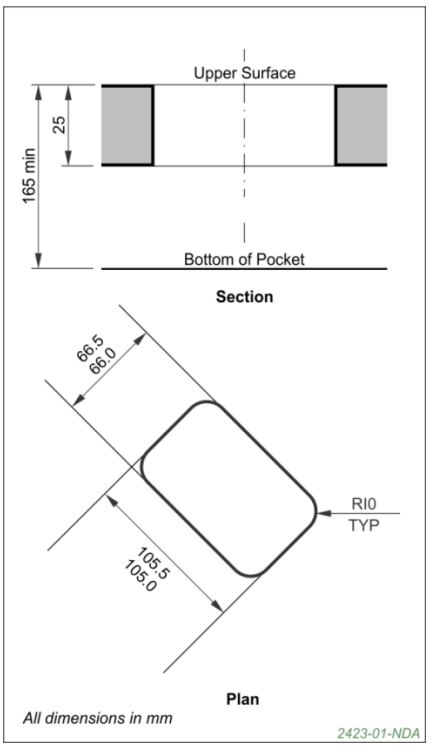

Figure 36 Schematic of the twistlock geometry and dimensions for the MBGWS Box.

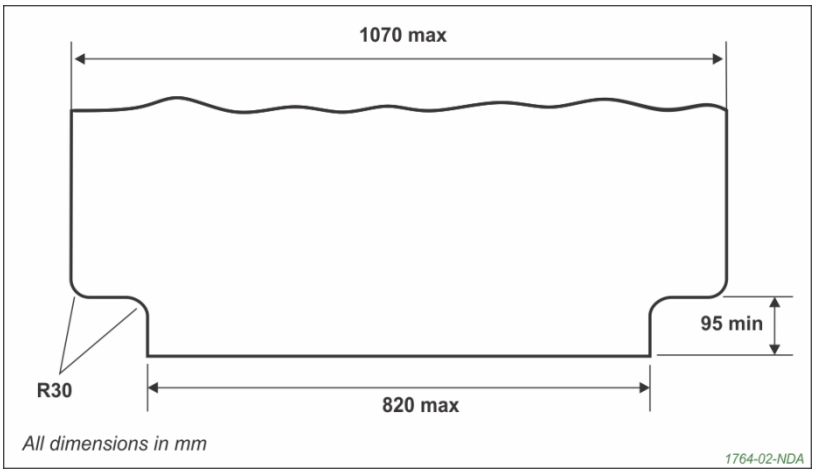

Figure 37 Schematic of the base handling feature of the 500 L Robust Shielded Drum.

Abbreviations

ACT	Accident Conditions of Transport
ALARP	As Low as Reasonably Practicable
DNLEU	Depleted Natural and Low Enriched Uranium
DSS	Disposal System Specification
GDF	Geological Disposal Facility
GDFD	Geological Disposal Facility Design
gDSSC	generic Disposal System Safety Case
gTSD	generic Transport System Design
IAEA	International Atomic Energy Agency
ISO	International Standards Organisation
LHGW	Low Heat Generating Waste
LSA	Low Specific Activity
NCT	Normal Conditions of Transport
NDA	Nuclear Decommissioning Authority
RWM	Radioactive Waste Management Limited
RSBTC	Robust Shielded Box Transport Container
SCO	Surface Contaminated Object
SFM	Safe Fissile Mass
SLC	Site License Company
SWTC	Standard Waste Transport Container
TCSC	Transport Container Standardisation Committee
TSC	Transport Safety Case
WPS	Waste Package Specification
WPSGD	Waste Package Specification and Guidance Documents

Glossary & Terminology

A_2	A unit of activity as defined by the IAEA Transport Regulations (Para 201). The A_2 is a measure of radiological significance of a specific nuclide to transport safety and is linked to possible exposure pathways to humans by the radiation emitted by that radionuclide.
Backfill	A material used to fill voids in a GDF.
Conditioning	Treatment of a radioactive waste material to create, or assist in the creation of a wasteform that has passive safety.
Exclusive Use	As defined by the IAEA Transport Regulations (Para 221).
Fissile Material	Defined by the IAEA Transport Regulations (Para 222). A fissile material is a material containing any of the following fissile nuclides; Uranium-233, Uranium-235, Plutonium-239 and Plutonium-241.
Immobilisation	A process by which the potential for the migration or dispersion of the radioactivity present in a material is reduced. This is often achieved by converting the material to a monolithic form that confers passive safety to the material.
Low Specific Activity (LSA)	As defined by the IAEA Transport Regulations (Para 226). LSA material refers to radioactive material that has a limited activity. There are three categories of LSA material (LSA-I, LSA-II and LSA-III).
Low Toxicity Alpha Emitters	As defined by the IAEA Transport Regulations (Para 227). They are considered as natural uranium, depleted uranium, natural thorium, uranium-235 or uranium-238; thorium-232, thorium 228 and thorium-230 when contained in ores or physical and chemical concentrates; or alpha emitters with a half-life of less than 10 days.
Nuclear Material	Ores, source material or special fissile material as defined in Article 197 of the Euratom Treaty.
Overpack	As defined by the IAEA Transport Regulations (Para 230). It refers to an enclosure used by a single consignor to contain one or more packages to form one unit for handling and storage during transport.
Safe Fissile Mass (SFM)	The quantity of fissile material that can be safely accommodated within a waste package, taking into account the nature of the fissile material, the presence of other materials of significance to criticality safety and the degree of characterisation of the waste package contents.
Specific Activity	As defined by the IAEA Transport Regulations (Para 240). The specific activity of a radionuclide is the activity per unit mass of that nuclide. The specific activity of a material is the activity per unit mass of the material in which the radionuclides are essentially uniformly distributed.
Surface Contaminated Objects (SCO)	As defined by the IAEA Transport Regulations (Para 241). A solid object that is not itself radioactive but which has radioactive material distributed on its surface.
Transport Package	As defined by the IAEA Transport Regulations (Para 231), this refers to the complete product of the packing operation, consisting of the packaging and its contents prepared for transport.
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.
Waste Container	Any vessel used to contain a wasteform for disposal.
Waste Package	The product of conditioning that includes the wasteform 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.

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