

**WASTE PACKAGE SPECIFICATION AND
GUIDANCE DOCUMENTATION**

**WPS/300: Specification for 500 litre
Drum Waste Package**

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Bibliography

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**WASTE PACKAGE SPECIFICATION AND GUIDANCE DOCUMENTATION
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/300 - VERSION HISTORY		
VERSION	DATE	COMMENTS
WPS/300/01	July 2005	Aligns with GWPS (Nirex Report N/104) as published June 2005
WPS/300/02	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. Changes comprise: Removal of RSTC Changes to NII SAPs and modelling of DBAs

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.

This document provides a specification for the 500 litre Drum waste package, one of a limited number of standard waste packages defined by RWMD. The specification is applicable to all aspects of the waste package and deals with the key features of the waste package including the performance requirements of the waste container, its contents (i.e. the wasteform) and the waste package as a whole. The specification makes reference to a number of supporting documents from the WPSGD which should be consulted as necessary. Of particular relevance is *500 litre Drum Waste Package Specification Explanatory Material and Design Guidelines, WPS/700*, which provides background information and justification of the specification criteria together with advice on their interpretation and guidance on their implementation.

2. BACKGROUND

2.1. The Concept of Geological Disposal

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

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

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

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

2.2. The Generic Waste Package Specification

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

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

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

² The generic description 'ILW' is used in the remainder of this document to describe both these categories of waste.

- 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.

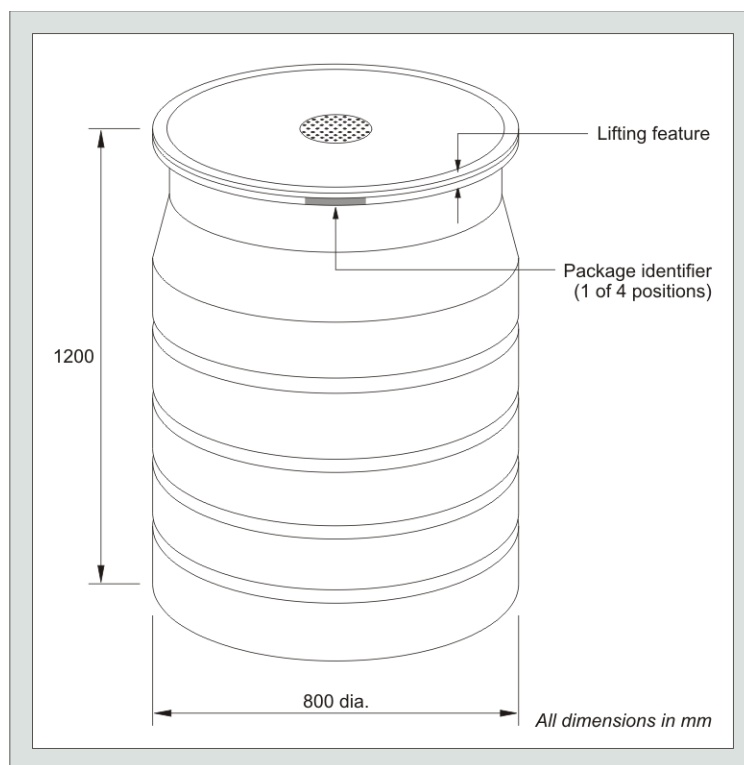
In undertaking LoC assessments RWMD determines whether wastes, when packaged, will have characteristics compliant with plans for transport to, and operations at a GDF, and ultimately whether the wastes could be accommodated within a GDF long-term post-closure safety case. The main output of a LoC assessment 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.

This specification is intended to provide waste packagers with a reference point against which waste packaging proposals can be progressed to the point at which a submission for assessment by way of the LoC process can be made. Waste packagers will find *Guidance on the Preparation of Letter of Compliance Submissions, WPS/908*, of assistance in this matter.

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 operation of nuclear facilities.

Figure 1 500 litre Drum Waste Package



The 500 litre Drum waste package 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 containers, 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 for use with:

- heterogeneous wasteforms - solid wastes in-filled with a fluid grout);

- homogenous wasteforms – liquid, sludge and slurry wastes, in-drum mixed with grout, and;
- annular grouted wasteforms – ‘pucks’ of compacted soft waste, surrounded by a grout annulus

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.

4. CRITERIA

This specification defines the key features and sets minimum standards of performance for 500 litre Drum waste packages, taking into account all of the requirements for long-term management. They are therefore appropriate for all stages of long-term management but shall be applied to waste packages at the time of transport from the waste packager’s site unless otherwise stated.

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. Activity Content

The waste package shall contain conditioned ILW or LLW and the activity content of the waste package shall be restricted, as necessary, to meet all other aspects of this specification (i.e. heat output, dose rate, criticality safety and normal operational and accident performance criteria).

The activity content of the waste package should not exceed $2.5 \times 10^4 A_2^3$.

4.2. Dose Rate

The surface dose rate from the waste package shall not exceed a value commensurate with achieving 2mSv h^{-1} at the surface, and 0.1mSv h^{-1} at 1 metre from the surface, of a 280mm steel shield (density 7700kg m^{-3}) in direct contact with a 2 x 2 array of identical waste packages.

4.3. Heat Output

The total heat output from the waste package should not exceed 50 watts at the time of transport and 25 watts at the time of vault backfilling⁴.

³ A_2 is a measure of activity linked to possible exposure pathways and defined in the IAEA Transport Regulations.

⁴ Assumed, for the purposes of this specification, to be 2090.

4.4. Surface Contamination

The non-fixed surface contamination of the waste package should be kept as low as reasonably achievable and, when averaged over an area of 300cm² of any part of the surface of the waste package, shall not exceed:

- 4.0Bqcm⁻² for beta, gamma and low toxicity⁵ alpha emitters and;
- 0.4Bqcm⁻² for all other alpha emitters.

4.5. Dimensions

The overall dimensional envelope of the waste package shall be (see Figure 2):

- Height: 1200mm +3mm/-15mm
- Diameter: 800mm +0mm/-6mm.

4.6. Lifting Feature

The waste package shall be capable of being lifted by a standard lifting grab, as described in *500 litre Drum Grab Description and Design Guidelines, WPS/600*, using a lifting feature in the form of a recessed flange as shown in Figure 3. The flange shall be located on the top face of the drum and shall provide access to locate the claws of a lifting attachment at any position around the periphery.

The waste package shall be capable of being lifted using this feature, with contact at no more than three equi-spaced positions, without exhibiting any permanent deformation under a force equivalent to twice the gross mass limit of the package.

The top face of the waste package 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 space shall have an inside diameter of 580mm, be a minimum of 60mm wide and no feature shall project into this space by more than 20mm above the top face of the drum flange.

4.7. Mass

The gross mass of the waste package should not exceed 2,000kg.

4.8. Gas Generation

The total gas generation rate for the waste package should not exceed 71 litres per day.

Specific limits are placed on the rates of generation of certain toxic, flammable and radioactive gases. Details of these limits can be found in Appendix A.

4.9. Venting

Waste packages that, by virtue of the nature of their container and/or contents, could be susceptible to pressurisation due to gas generation at any time during their long-term management, shall incorporate an engineered vent designed to retain significant particulate activity.

⁵ Defined 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.

4.10. Integrity

The integrity of the waste package shall be such that it is capable of retaining its contents and of being moved and handled safely and efficiently, as required, during all stages of long-term management.

The waste packages should be designed so that:

- following a period of interim surface storage, currently assumed to be up to 150 years, the waste package shall meet the requirements for handling and for transport to a GDF;
- following emplacement in a GDF, the waste package should be capable of maintaining its integrity for the operational period, currently assumed to be 50 years;
- upon cessation of the operational period, the waste package should retain integrity during a period of care and maintenance, during which time the waste package must be capable of being retrieved and safely handled. This period could extend to a few hundred years;
- following the period of care and maintenance, a GDF may be backfilled. The waste package should continue to retain its integrity for a period consistent with the containment of short-lived soluble radionuclides.

A period of 500 years should be considered a target for the integrity of the waste container.

4.11. Properties of the Wasteform

During the production of the wasteform and the interim surface storage of the waste package, all reasonable measures shall be taken to ensure that:

- radionuclides in the waste are immobilised;
- loose particulate material is minimised;
- free liquids are excluded;
- hazardous materials are excluded or made safe;
- toxic materials are minimised;
- any gases generated do not result in pressurisation of the wasteform; and
- the presence and volume of voids (e.g. ullage space) is minimised.

The measures taken to achieve these objectives should include an anticipation of the effects of ageing on the performance of the wasteform.

Reference should be made to *Specification for Wasteform for 500 litre Drum Waste Package, WPS/500*, which provides a full specification for wasteform performance and to *Specification for Wasteform for 500 litre Drum Waste Package: Explanatory Material and Guidance, WPS/800*, which provides background information and justification of the wasteform criteria together with guidance and advice on their interpretation.

4.12. Criticality Safety

The presence of fissile materials⁶, 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.

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 the facility.

4.13. Impact Performance

The waste package should be designed such that, in the event of an impact accident:

- releases of radionuclides and other hazardous materials are low and predictable, exhibit progressive release behaviour with increasing impact severity and do not exhibit significant cliff-edge performance characteristics within the anticipated range of impact conditions;
- both of the barriers to radionuclide release from the waste package (i.e. the waste container and the wasteform) should play an effective role in minimising those releases.

The waste package shall be capable of being dropped, in any attitude, from a height of 0.3 metres onto a flat unyielding surface, whilst retaining its radioactive contents, and afterwards shall remain suitable for safe handling during all subsequent stages of their long-term management.

The release of radioactive contents from the waste package, as a result of credible impact accidents during transport and the operational period of a GDF, shall not result in the relevant regulatory radiation dose limits to workers or to members of the public being exceeded.

4.14. Fire Performance

The waste package should be designed such that in the event of a fire accident:

- releases of radionuclides and other hazardous materials are low and predictable, exhibit progressive release behaviour with increasing fire severity and do not exhibit significant cliff-edge performance characteristics within the anticipated range of impact conditions;
- both of the barriers to radionuclide release from the waste package (i.e. the waste container and the wasteform) should play an effective role in minimising those releases.

The release of radioactive contents from the waste package, as a result of credible fire accidents during transport and the operational period of a GDF, shall not result in the relevant regulatory radiation dose limits to workers or to members of the public being exceeded.

⁶ Defined as U-233, U-235, Pu-239 and Pu-241 but excepting unirradiated natural or depleted uranium and natural or depleted uranium that has been irradiated in a thermal reactor.

4.15. Stackability

The waste package shall be capable of being stacked six high. The stacking load on the waste package shall be calculated as that resulting from its support of five similar packages each with a gross mass of 2,000kg, applied along the vertical axis of the waste package. Under these load conditions, the waste package should not exhibit any permanent deformation or abnormality that would render it incompatible with any of the requirements defined in this specification.

4.16. Identification

The waste package shall be marked with an unique alpha-numeric identifier as defined in *Specification of Waste Package Identification System, WPS/410*. The identifier shall be marked at four equally spaced positions on the vertical edge of the waste package lifting feature as shown in Figure 2. The characters shall be 6-10mm high and should be capable of being read during all active stages of long-term waste management.

4.17. Nuclear Security Physical Protection

The quantity of Nuclear Material contained within the waste package shall be such that the waste package can be transported subject to standards of physical protection no higher than Category III.

4.18. Safeguards

The Safeguards status of any fissile or source materials (i.e. isotopes of uranium, plutonium and thorium) contained within a waste package shall be ascertained and recorded.

5. QUALITY MANAGEMENT

Quality management arrangements shall be applied to all aspects of the packaging of radioactive wastes that affect product quality. These arrangements shall be agreed with RWMD prior to the start of the activities to which they relate.

The requirements for the quality management arrangements for waste package production are detailed in *Waste Package Quality Management Specification, WPS/200*.

6. WASTE PACKAGE DATA AND INFORMATION RECORDING

Information shall be recorded on all relevant details of the manufacture of each waste package. That information shall be sufficient to enable assessment of the waste package characteristics and performance against the requirements of all stages of their long-term management.

The information to be recorded is detailed in *Waste Package Data and Information Recording Requirements, WPS/400*.

Figure 2 Standard Features of the 500 litre Drum Waste Package

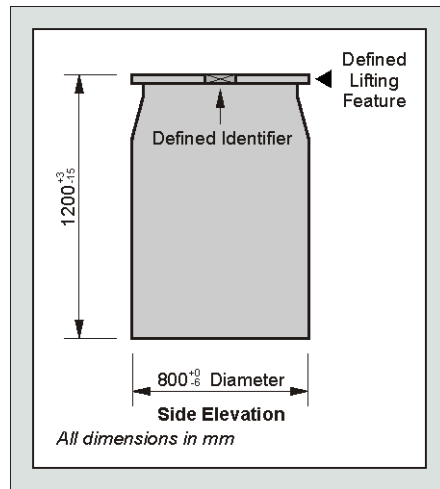
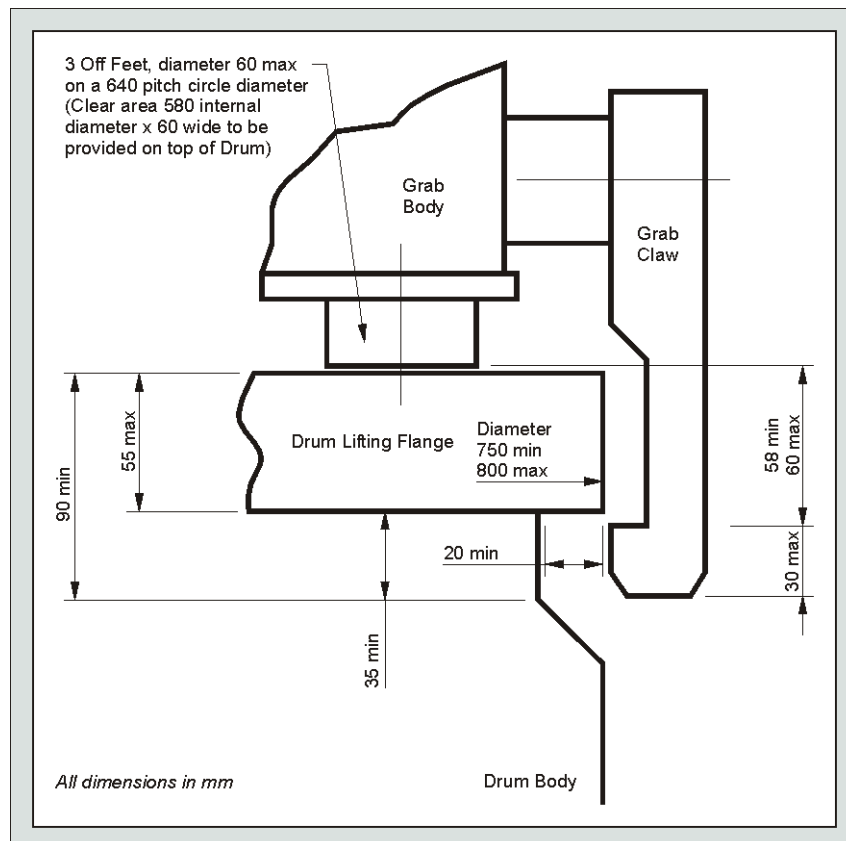


Figure 3 Standard Lifting Feature for 500 litre Drum Waste Package



APPENDIX A WASTE PACKAGE GAS GENERATION LIMITS

Table A.1 Flammable Gas Generation Limits

Gas	Lower Flammability Limit	Gas Generation Limit⁷
	(%)	(litres/day)
Ammonia	16	1.88
Benzene	1	0.10
Butylamine	2	0.21
Carbon disulphide	1	0.10
Cyclohexane	1	0.10
Furfural	2	0.21
Heptane	1	0.10
Hydrogen	4	0.43
Hydrogen sulphide	4.3	0.46
Methane	5.6	0.60
Styrene	1	0.10
Toluene	1	0.10
Trichloroethylene	13	1.49
Oxygen generation limit when nitrogen purging is applied		0.25

Table A.2 Toxic Gas Generation Limits

Gas	Gas Generation Limit (litres/day)
Arsine	26.6
Hydrogen selenide	26.6
Nickel carbonyl	26.6
Ozone	49.3
Phosphorous oxychloride	49.3
Stibine	49.3

⁷ Above which nitrogen purging of the Transport Container would be required

Table A.3 Radioactive Gas Generation Limits

Nuclide	Allowable activity release (TBq/day)
Ar-41	1.3 x 10 ⁻⁴
Ar-39	8.5 x 10 ⁻³
C-14	1.3 x 10 ⁻³
H-3	4.1 x 10 ⁻³
Kr-81	1.8 x 10 ⁻²
Kr-85	4.2 x 10 ⁻⁴
Kr-85m	1.3 x 10 ⁻³
Kr-87	8.5 x 10 ⁻⁵
Rn-222	1.8 x 10 ⁻⁶
Xe-122	1.8 x 10 ⁻⁴
Xe-123	2.9 x 10 ⁻⁴
Xe-127	8.5 x 10 ⁻⁴
Xe-131m	1.8 x 10 ⁻²
Xe-133	4.2 x 10 ⁻³
Xe-135	8.5 x 10 ⁻⁴

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