Radioactive Waste Management

NDA Report no. DSSC/302/01

Geological Disposal

Transport Package Safety Report

December 2016

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Conditions of Publication

ISBN 978-1-84029-544-3

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Preface

Radioactive Waste Management Limited (RWM) has been established as the delivery organisation responsible for the implementation of a safe, sustainable and publicly acceptable programme for the geological disposal of the higher activity radioactive wastes in the UK. As a pioneer of nuclear technology, the UK has accumulated a legacy of higher activity wastes and material from electricity generation, defence activities and other industrial, medical and research activities. Most of this radioactive waste has already arisen and is being stored on an interim basis at nuclear sites across the UK. More will arise in the future from the continued operation and decommissioning of existing facilities and the operation and subsequent decommissioning of future nuclear power stations.

Geological disposal is the UK Government's policy for higher activity radioactive wastes. The principle of geological disposal is to isolate these wastes deep underground inside a suitable rock formation, to ensure that no harmful quantities of radioactivity will reach the surface environment. To achieve this, the wastes will be placed in an engineered underground facility – a geological disposal facility (GDF). The facility design will be based on a multi-barrier concept where natural and man-made barriers work together to isolate and contain the radioactive wastes.

To identify potentially suitable sites where a GDF could be located, the Government has developed a consent-based approach based on working with interested communities that are willing to participate in the siting process. The siting process is on-going and no site has yet been identified for a GDF.

Prior to site identification, RWM is undertaking preparatory studies which consider a number of generic geological host environments and a range of illustrative disposal concepts. As part of this work, RWM maintains a generic Disposal System Safety Case (DSSC). The generic DSSC is an integrated suite of documents which together give confidence that geological disposal can be implemented safely in the UK.

Executive Summary

Radioactive Waste Management Limited (RWM) is responsible for implementing a geological disposal facility (GDF) for higher activity wastes, as set out in the UK Government's White Paper on a framework for the long term management of higher activity waste.

The White Paper defines an inventory of materials that may need to be managed through geological disposal: High Level Waste (HLW), Intermediate Level Waste (ILW), some Low Level Waste (LLW) unsuitable for near-surface disposal, spent fuel (SF), depleted natural and low-enriched uranium, highly-enriched uranium and separated plutonium.

In 2010 RWM produced an initial generic Disposal System Safety Case (generic DSSC). The generic DSSC explains and assesses the safety and environmental implications of the geological disposal of radioactive waste in the UK.

The generic DSSC addresses the following phases of the disposal system:

- transporting the waste to the GDF – the safety arguments and assessment of this phase – presented in the **generic Transport Safety Case (TSC)**
- construction of the GDF and emplacement of waste within it, and the eventual backfilling, decommissioning and closure of the GDF – presented in the **generic Operational Safety Case (OSC)**
- the environmental safety of the GDF during the operational period and after closure of the facility – presented in the **generic Environmental Safety Case (ESC)**

There are now a number of drivers for updating the generic DSSC as an entire suite of documents, most notably the availability of an updated inventory for disposal.

The aim of the generic TSC is to provide assurance to RWM, the regulators, other stakeholders and the public that the transport operation can be achieved safely, with radiation exposures below statutory limits and RWM's own criteria, and as low as reasonably practicable (ALARP).

The generic TSC comprises the following, each of which has its own supporting documentation:

- Transport Package Safety (TPS) report, this document, which describes the means by which the safety of transporting a package to the GDF is ensured. It describes the procedures, assessments and approvals that could be used.
- Generic Transport Safety Assessment (TSA), which reports on a safety assessment of the transport of radioactive wastes from waste producing sites to the GDF

The safety arguments made in the generic TSA and the TPS report are drawn together and summarised in the generic TSC Main Report.

This document updates and replaces the 2010 TPS report, which was published as part of the 2010 generic DSSC suite. Its objectives are:

- to describe the measures that are or will be in place to ensure the safe transport of radioactive waste packages to the GDF by road, rail or sea
- to provide assurance that packages will be transported safely
- to describe the wastes, proposals for waste packaging, the waste containers and the reusable transport containers in which some waste packages are placed for transport and also to describe the transport package approval process

The safety of transporting radioactive materials falls under a stringent regulatory regime that has been continuously revised and updated. Safety measures have been developed to protect people, property and the environment against the hazards posed by

conveyances of radioactive material. The international regulatory standards for the transport of radioactive materials are the IAEA Regulations for the Safe Transport of Radioactive Material (IAEA Transport Regulations). In the UK these regulations are implemented for rail and road transport as the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (the CDG Regulations) and for sea as the Merchant Shipping Regulations. The CDG Regulations and the Merchant Shipping Regulations are enforced by the Office for Nuclear Regulation (ONR) for civil waste and by the Defence Nuclear Safety Regulator (DNSR) for defence waste.

The IAEA Transport Regulations specify criteria that must be met by each transport package, for example, on external dose rate and surface temperature. The regulations also require demonstration of the ability of transport packages to withstand certain physical challenges, and to satisfy other tests that simulate their performance under normal conditions and in accidents.

The fundamental principle applied to the transport of radioactive material is that safety is to be ensured by the design of the packages and limits imposed on their contents. Thus, safety is inherent in the package design rather than dependent on operational and procedural controls, such as restrictions on transport modes or routes. The package design and safety performance requirements are related to the potential hazard of the radioactive material being transported.

In addition to the package design requirements, transport safety is enhanced by assigning appropriate responsibilities to all transport operators including the consignor, carrier and consignee. The IAEA Transport Regulations specify requirements for appropriate administrative and operational controls, quality assurance, training and expertise, security and emergency provisions and accident reporting.

Compliance of a transport package with the design requirements of the IAEA Transport Regulations is demonstrated by a Design Safety Report (DSR) which includes all the information required to demonstrate the safety of the package and which establishes clear limits on key package safety parameters such as dose rate, containment of contents and limits on fissile contents.

Package and material designs need to be checked and approved for compliance with the requirements of the IAEA Transport Regulations. The design authority is required to gain approval for such designs, and does so by producing a DSR. For certain package or material designs, that is, those pertaining to higher hazard radioactive materials, the DSR is submitted to a competent authority for approval. The legal competent authority in the UK for transport of civil waste is currently the Office for Nuclear Regulation. The legal competent authority for transport of defence waste is the Secretary of State for Defence (with the DNSR acting as the regulator). For other designs, that is those pertaining to lower hazard radioactive materials, self-approval by the design authority is sufficient, and is subject to audit by the competent authority.

In order to demonstrate approval, all material and package designs must have associated documentary evidence of the compliance of the design with applicable requirements. A competent authority will issue a Certificate of Approval (CoA) when approval is granted, and bodies undertaking self-approval also issue evidence, usually in the form of a CoA.

At this early stage in the development of the geological disposal system, packaging operations are already underway at the waste producing sites and some waste packages have already been manufactured and placed in interim storage awaiting transport to the GDF. In addition, waste packagers need to make plans for manufacture and storage of packages for future waste arisings. Compliance of these packages with regulations and RWM's own requirements for transport and disposal is assessed as part of RWM's Disposability Assessment process. This process allows waste packaging to proceed with confidence that packages will be suitable for transport and disposal.

RWM expects that any waste package made now will be periodically reviewed and will have a detailed history, including waste conditioning and storage records. It is expected that such packages will be compliant with a future CoA and will therefore be acceptable for transport to the GDF. It will be necessary to confirm this acceptability prior to despatch.

Following confirmation of the suitability for transport, the waste package can be retrieved from interim storage, checked to confirm that it meets the requirements of both the transport package approval and GDF waste acceptance criteria, and loaded into a transport container, where applicable. The transport package can then be loaded onto the transport conveyance and cleared for despatch. These activities will be specified in detailed procedures and local work instructions prepared by the consignor to meet the requirements set out in the CoA.

Confidence that transport packages appropriate to the full range of wastes in the inventory can be made is based on a long history and experience of radioactive material transport, with packages having been produced for many different wastes. This is backed up by the Disposability Assessment process, in which the suitability of packaging proposals for specific wastes in the inventory is evaluated.

In summary, this report is part of the generic DSSC and demonstrates the ability of the waste packages to comply with anticipated transport requirements. Through demonstration of compliance with the IAEA Transport Regulations, satisfaction of regulators' expectations and transparency to stakeholder scrutiny, it gives assurance that a package containing radioactive material will be safe for transport and disposal.

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1 Introduction

1.1 The generic Disposal System Safety Case

RWM has been established as the delivery organisation responsible for the implementation of a safe, sustainable and publicly acceptable programme for geological disposal of the UK's higher activity radioactive waste. Information on the approach of the UK Government and devolved administrations of Wales and Northern Ireland[1] to implementing geological disposal, and RWM's role in the process, is included in an overview of the generic Disposal System Safety Case (the Overview) [1].

A geological disposal facility (GDF) will be a highly-engineered facility, located deep underground, where the waste will be isolated within a multi-barrier system of engineered and natural barriers designed to prevent the release of harmful quantities of radioactivity and non-radioactive contaminants to the surface environment. To identify potentially suitable sites where a GDF could be located, the Government is developing a consent-based approach based on working with interested communities that are willing to participate in the siting process [2]. Development of the siting process is ongoing and no site has yet been identified for a GDF.

In order to progress the programme for geological disposal while potential disposal sites are being sought, RWM has developed illustrative disposal concepts for three types of host rock. These host rocks are typical of those being considered in other countries, and have been chosen because they represent the range that may need to be addressed when developing a GDF in the UK. The host rocks considered are:

- higher strength rock, for example, granite
- lower strength sedimentary rock, for example, clay
- evaporite rock, for example, halite

The inventory for disposal in the GDF is defined in the Government White Paper on implementing geological disposal [2]. The inventory includes the higher activity radioactive wastes and nuclear materials that could, potentially, be declared as wastes in the future. For the purposes of developing disposal concepts, these wastes have been grouped as follows:

- High heat generating wastes (HHGW): that is, spent fuel from existing and future power stations and High Level Waste (HLW) from spent fuel reprocessing. High fissile activity wastes, that is, plutonium (Pu) and highly enriched uranium (HEU), are also included in this group. These have similar disposal requirements, even though they don't generate significant amounts of heat.
- Low heat generating wastes (LHGW): that is, Intermediate Level Waste (ILW) arising from the operation and decommissioning of reactors and other nuclear facilities, together with a small amount of Low Level Waste (LLW) unsuitable for near surface disposal, and stocks of depleted, natural and low-enriched uranium (DNLEU).

[1] Hereafter, references to Government mean the UK Government including the devolved administrations of Wales and Northern Ireland. Scottish Government policy is that the long term management of higher activity radioactive waste should be in near-surface facilities and that these should be located as near as possible to the site where the waste is produced.

RWM has developed six illustrative disposal concepts, comprising separate concepts for HHGW and LHGW for each of the three host rock types. Designs and safety assessments for the GDF are based on these illustrative disposal concepts.

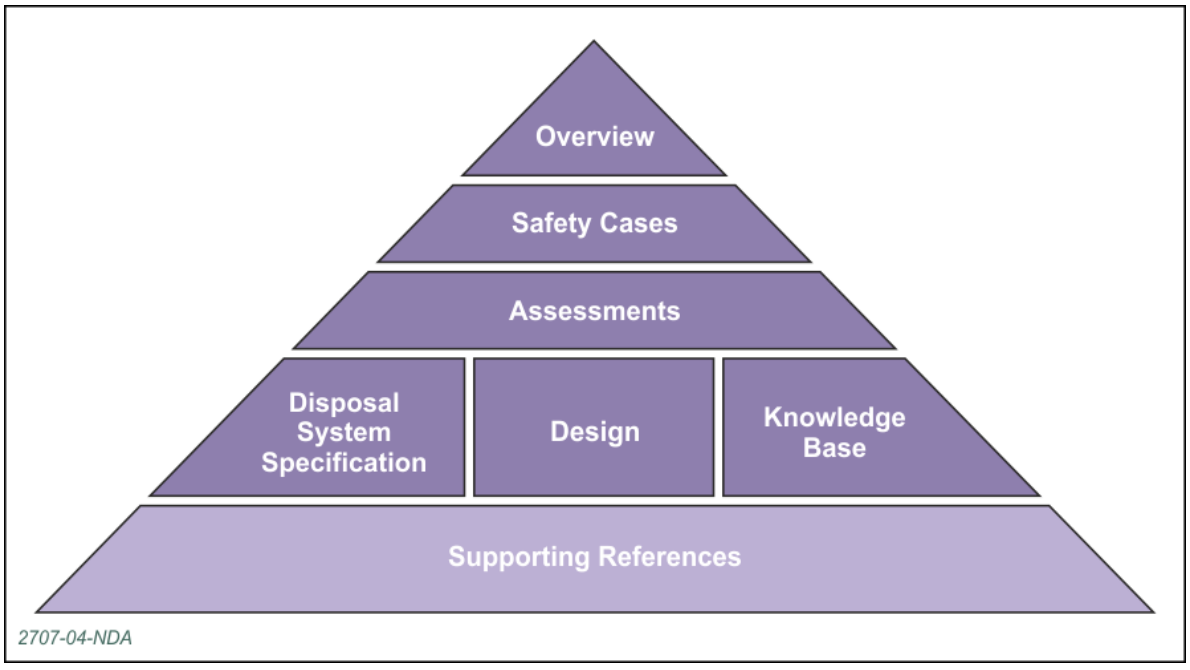
High level information on the inventory for disposal, the illustrative disposal concepts and other aspects of the disposal system is collated in a technical background document (the Technical Background) [3] that supports this generic Disposal System Safety Case.

The generic Disposal System Safety Case (DSSC) plays a key role in the iterative development of a geological disposal system. This iterative development process starts with the identification of the requirements for the disposal system, from which a disposal system specification is developed. Designs, based on the illustrative disposal concepts, are developed to meet these requirements, which are then assessed for safety and environmental impacts. An ongoing programme of research and development informs these activities. Conclusions from the safety and environmental assessments identify where further research is needed, and these advances in understanding feed back into the disposal system specification and facility designs.

The generic DSSC provides a demonstration that geological disposal can be implemented safely. The generic DSSC also forms a benchmark against which RWM provides advice to waste producers on the packaging of wastes for disposal.

Document types that make up the generic DSSC are shown in Figure 1. The Overview provides a point of entry to the suite of DSSC documents and presents an overview of the safety arguments that support geological disposal. The safety cases present the safety arguments for the transportation of radioactive wastes to the GDF, for the operation of the facility, and for long-term safety following facility closure. The assessments support the safety cases and also address non-radiological, health and socio-economic considerations. The disposal system specification, design and knowledge base provide the basis for these assessments. Underpinning these documents is an extensive set of supporting references. A full list of the documents that make up the generic DSSC, together with details of the flow of information between them, is given in the Overview.

Figure 1 Structure of the generic DSSC



1.2 Document purpose

This document is the Transport Package Safety (TPS) report and is one of three reports that make up the generic Transport Safety Case (generic TSC). At the same tier in the hierarchy is the generic Transport Safety Assessment (generic TSA) [4] which, together with this TPS report, underpin the generic TSC Main Report [5].

The generic DSSC was previously published in 2010. There are now a number of drivers for updating the safety case as an entire suite of documents, most notably the availability of an updated inventory for disposal [6].

This document updates and replaces the 2010 TPS report [7], which was published as part of the 2010 generic DSSC suite. This issue includes the following improvements:

- information relating to the International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material [8] (hereafter referred to as the IAEA Transport Regulations) has been updated to take account of revisions to the regulations, for example, in relation to new provisions for classification of material as fissile excepted
- changes to the geological disposal system (for example the inclusion of new package types such as the 500 litre robust shielded drum, 3 cubic metre robust shielded box and strengthened stainless steel transport and disposal container (TDC)) have been implemented in so far as they apply to transport safety
- RWM's strategy in relation to transport safety has been clarified
- technical background information duplicated across the 2010 generic DSSC documents so that they may stand alone has been removed and placed in the Technical Background to avoid repetition
- progress on the development of package contents specifications and criticality safety assessments where RWM is the design authority has been updated
- the arrangements for ensuring transport safety where RWM is not the design authority have been clarified
- information presented in the 2010 TPS report on progress made on waste packaging endorsements has been removed to avoid repetition with other published documents [9]

1.3 Objectives

The generic TSC has the following objectives:

Primarily, it provides confidence that the transport of radioactive waste to the GDF will be safe, without being specific to any potential GDF location. This forms part of RWM's demonstration to regulators and stakeholders that geological disposal and transport are feasible.

It also fills an important role in providing a basis against which waste packaging proposals submitted by waste packagers are assessed under the RWM Disposability Assessment process [10] to determine whether the proposed packages are likely to be transportable in the future.

It provides a vehicle for engaging with stakeholders, such as waste packagers and communities interested in hosting the GDF on topics related to transport safety.

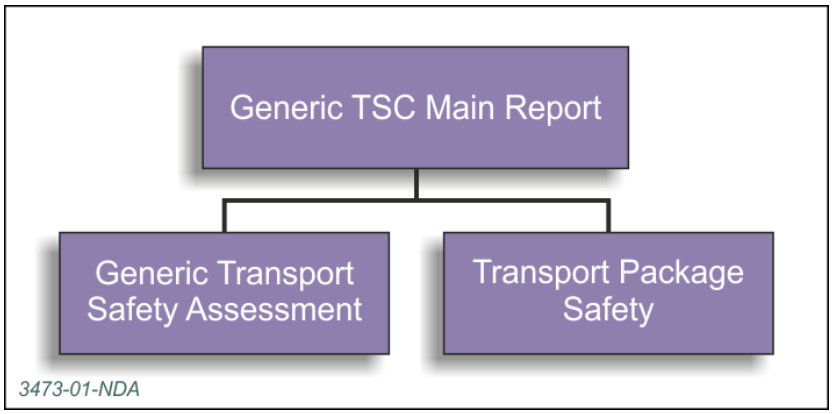
Lastly, the generic TSC informs RWM's generic science and technology plan [11] as part of the iterative approach to implementing geological disposal.

These objectives are met by the following documents that make up the generic TSC:

- **TPS report:** this document, which describes the means by which the safety of transporting a package to the GDF is ensured. It describes the procedures, assessments and approvals that are, or will be, in place.
- **Generic Transport Safety Assessment:** which reports on a safety assessment of the transport of radioactive wastes from waste producing sites to the GDF. It is against this that an assessment of dose from waste packaging proposals is compared as part of the Disposability Assessment process. It also provides a basis for the prior dose evaluation, which is a requirement of the Radiation Protection Programme (RPP) that must be produced prior to transport.

The structure of the generic TSC is shown in Figure 2. The safety arguments made in the generic TSA and the TPS report are drawn together and summarised in the generic TSC Main Report.

Figure 2 Structure of the generic TSC



1.4 Scope of the TPS report

This report describes the following processes, principles and requirements:

- regulatory requirements on the design and approval of transport package designs
- RWM's Disposability Assessment process for assessing waste packaging proposals submitted by waste packagers, to determine whether the proposed packages are expected to be transportable in the future
- pre-despatch activities that will be necessary prior to transport to ensure that a package remains compliant with the requirements of transport and the Waste Acceptance Criteria (WAC) for disposability

The scope of transport to which the IAEA Transport Regulations apply is defined as the transport of radioactive material by all modes on land, water, or in the air, including transport that is incidental to the use of the radioactive material. Transport comprises all operations and conditions associated with, and involved in, the movement of radioactive material; these include the design, manufacture, maintenance and repair of packaging, and the preparation, consigning, loading, carriage including in-transit storage, unloading and receipt at the final destination of loads of radioactive material and packages.

The scope of the transport system considered by the generic TSA begins at the point where transport packages are secured onto a transport vehicle at a consigning site for dispatch to the GDF and concluding at the point where responsibility for the transport packages is handed over to operators at the GDF.

The audience of this report is expected to be regulators, RWM and waste packagers. The public and other stakeholders may also take an interest. Specifically:

- the radioactive material transport regulators: ONR and the Defence Nuclear Safety Regulator (DNSR)
- waste packagers, in order for them to understand the requirements for packaging waste so that it is suitable for transport to the GDF

1.5 Document structure

The processes for demonstrating transport safety are set out in the remaining sections of this report as follows:

- Section 2 provides contextual information on the regulatory framework and sets out RWM's strategic position as representing the role of the consignor, carrier and consignee
- Section 3 sets out the assessment basis by identifying the documents that set out the description of the transport system and radioactive wastes to be transported within the planned transport operation
- Section 4 describes the processes of transport package approval and the related safety documentation
- Section 5 summarises the Disposability Assessment process and describes the aspects relevant to transport safety. This process has been developed by RWM to provide an early check that waste packaged now is done so in a way that will meet IAEA Transport Regulations in the future and will meet RWM's criteria for transport and disposal
- Section 6 describes the pre-despatch activities necessary to demonstrate that waste packages still meet the requirements of both the Certificate of Approval (CoA) or equivalent documentation, which sets out the requirements for transport, and the Waste Acceptance Criteria (WAC) for the GDF which set out the requirements for disposability
- Section 7 presents a summary of the system and processes that must be in place to demonstrate that the transport of waste packages is safe

2 Regulatory Context

The transportation of radioactive materials in the UK has to meet the requirements of the Carriage of Dangerous Goods Regulations 2009 [12], as amended by the Carriage of Dangerous Goods Regulations 2011 [13]. These regulations implement provisions of European legislation on the carriage of dangerous goods and, in particular, the requirements contained in:

- the European Agreement concerning the International Carriage of Dangerous Goods by Road (generally referred to as 'ADR') [14]
- the Regulations concerning the International Carriage of Dangerous Goods by Rail (generally referred to as 'RID') [15]

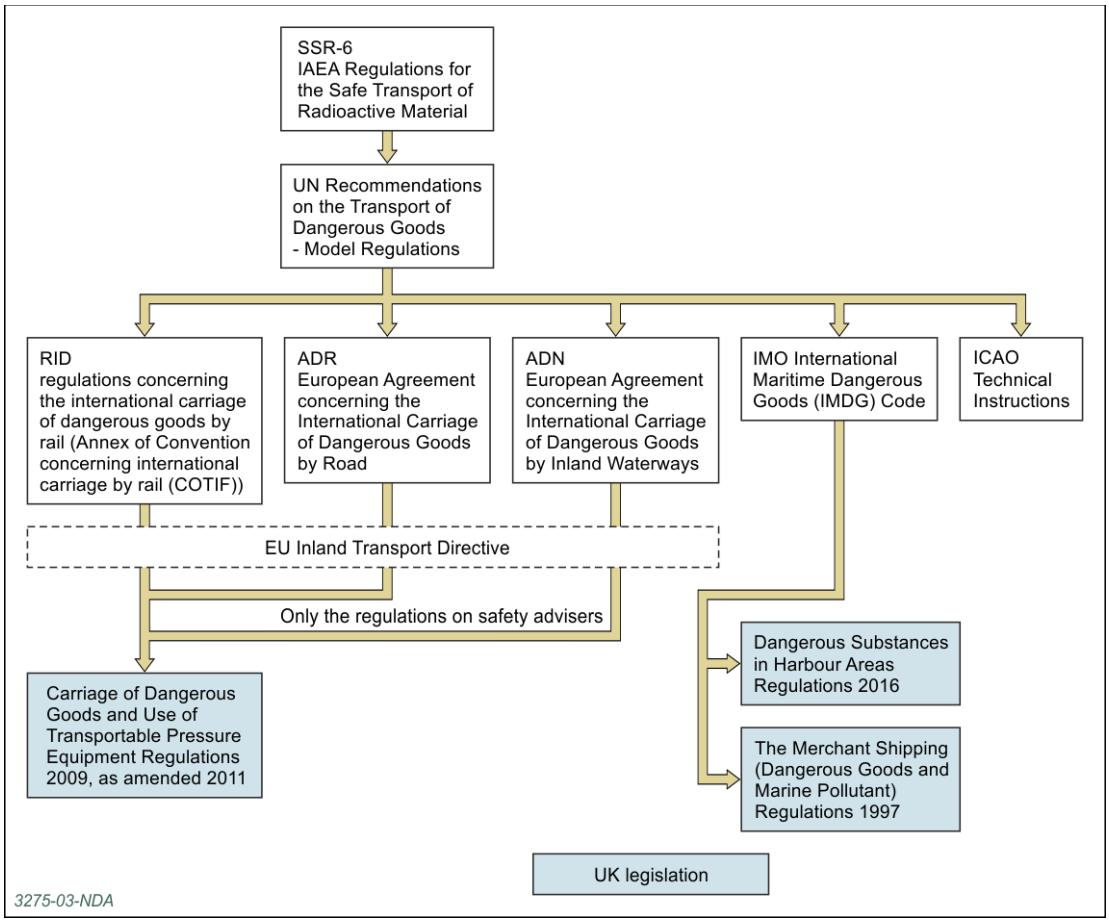
The transportation of radioactive wastes and materials by sea has to meet the requirements of Merchant Shipping Regulations [16] and Dangerous Substances in Harbour Areas [17]. The International Maritime Dangerous Goods (IMDG) Code [18] provides the basis of UK maritime legislation for the safe transportation or shipment of dangerous goods or hazardous materials, including radioactive materials. The current version of the IMDG code is invoked as regulation by the Merchant Shipping Notices (MSNs): the current relevant MSN number is 1854 [19].

The generic TSC does not address carriage by inland waterway but if a site is identified that makes transport by such a waterway feasible, then RWM will discuss the implementation of the relevant agreement: the European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways (generally referred to as 'ADN') [20], with the regulator.

Air transport is not considered feasible for radioactive waste due to the large quantities and mass of the packages, hence the regulations governing air transport are not cited here.

The international agreements, ADR, RID, ADN and the IMDG Code, are based upon the Recommendations on the Transport of Dangerous Goods Model Regulations published by the United Nations [21], of which the requirements for the transport of radioactive material are based upon the IAEA Transport Regulations [8]. The relationship between the international agreements and UK legislation is shown in Figure 3.

Figure 3 Regulations and agreements on radioactive material transport



The IAEA Transport Regulations address all operations and conditions associated with, and involved in, the safe movement of radioactive material. These include the design, manufacture, maintenance and repair of packaging and the preparation, loading, carriage (including in-transit storage), unloading and receipt at the final destination of radioactive material and packages.

Hence, the demonstration of safety in the transport of all radioactive material, including radioactive waste, starts with the requirements of the IAEA Transport Regulations. These regulations specify criteria that must be met by each transport package, for example, on external dose rate and surface temperature. They also require demonstration of the ability of transport packages to withstand certain physical tests to ensure that they will remain safe in normal transport conditions and potential accidents during transport.

Responsibility for demonstrating and providing a safe transport operation will be shared between a number of organisations, for example consignors, carriers and the consignee (the GDF operator). One of RWM's strategic principles is that until such time as these responsibilities are assigned, RWM will represent the role of waste consignor, carrier and the consignee and take responsibility for developing and implementing its transport safety strategy [24].

3 Assessment Basis

The generic transport system comprises:

- the transport package (which includes the package inventory, the wasteform, the waste container and, if used, a transport container)
- the transport conveyances (for example, road trailer or rail wagon)
- the transport infrastructure
- operating and maintenance procedures in so far as they apply to transport
- routes and modes of transport

These elements are described in the Generic Transport System Design [22]. Together with the inventory for disposal, they define the assessment basis. A broad and high-level description of the disposal system, including the inventory of wastes, the Disposal System Specification, requirements for packaging waste, illustrative concept designs and the development of the knowledge base is given in the Technical Background [3].

4 Transport Package Approval and Safety Documentation

Package and material designs need to be checked and approved for compliance with the requirements of the IAEA Transport Regulations. The design authority, that is, the organisation that produced the design, is required to gain approval for such designs, and does so by producing a Design Safety Report (DSR). For certain package or material designs, that is, those pertaining to higher hazard radioactive materials, the DSR is submitted to the competent authority for approval. The legal competent authority in the UK for transport of civil waste is currently the Office for Nuclear Regulation [23]. The legal competent authority for transport of defence waste is the Secretary of State for Defence [12] (with the DNSR acting as the regulator). For other designs, that is those pertaining to lower hazard radioactive materials, self-approval by the design authority is sufficient, and this is often done by an internal nominated approval authority. Self-approval is subject to audit by the competent authority.

In order to demonstrate approval, all material and package designs must have associated documentary evidence of the compliance of the design with applicable requirements. A competent authority will issue a CoA when approval is granted, and bodies undertaking self-approval also issue evidence, usually in the form of a CoA. The CoA or equivalent document includes a specification of the radioactive contents together with details of the controls needed for the preparation, handling and carriage of any consignment.

Applications for approval of a package design can be generic in that they are based on bounding case inventories, and this can provide flexibility for packaging designs that are likely to apply to a wide range of materials.

A further requirement of the IAEA Transport Regulations is the preparation of a Radiation Protection Programme (RPP). The RPP documents the framework of controls applied by a transport organisation to satisfy fundamental radiation protection principles, in particular to limit normal and potential exposures of workers and members of the public. An important element of the RPP is a prior dose evaluation, and one of the purposes of the generic and future site-specific TSAs is to provide a basis for such evaluation.

This section outlines the requirements of the IAEA Transport Regulations, describes the process for applying for a CoA, and details the content of the DSR and the role of the RPP.

4.1 Background to the IAEA Transport Regulations

RWM's Corporate Strategy [24] notes that radioactive waste has been transported within the UK, and to and from the UK, for the last 50 years without serious incident. This has included road and rail transport of fuel and spent fuel to and from reactor sites throughout the country. The LLW repository near the village of Drigg in West Cumbria has provided a disposal facility for LLW since 1959 and has accepted road and rail shipments from nuclear licensed sites throughout the UK. There have also been many transfers of fuel and spent fuel out of and into the country by sea.

The safety of the transport of radioactive materials is ensured by compliance with the stringent regulatory regime set out in the IAEA Transport Regulations and consequential national legislation. These regulations were first published in 1961 and are regularly reviewed to ensure they keep pace with scientific and technological developments. They are based on the fundamental principle that transported radioactive material should be packaged adequately to *'protect persons, property and the environment from all the effects of ionising radiation during the transport of radioactive material'*. This principle applies to routine (incident free), normal (including minor mishaps) and accident conditions of transport with minimal reliance on operational controls. Therefore, safety and protection is to be provided by the design of the package for all transport modes. Consequently, under

the IAEA Transport Regulations, protection and safety is vested in the package by the requirement to provide impact and thermal protection through:

- containment of the radioactive contents during handling and transport (Containment System)
- control of external radiation levels (for example by shielding)
- prevention of nuclear criticality in the case of fissile material
- prevention of the damage caused by heat (for example by heat dissipation)

The IAEA Transport Regulations also embrace the principle that the likelihood of incurring radiation exposure should be kept 'as low as reasonably practicable' (ALARP) and require that an RPP be established for the transport of radioactive material [8, Section III]. The nature and extent of the RPP shall be related to the magnitude and likelihood of radiation exposure. The application of the ALARP principle is considered in the generic TSA, which presents a generic dose assessment that could in the future be adapted for a specific site to inform the RPP. The requirements of an RPP are summarised later in this section.

The required level of protection and safety is achieved by adopting sound package design and manufacturing principles that call upon built-in safety, rather than on human intervention. The package design and safety performance requirements are related to the potential hazard of the radioactive materials being transported: the more hazardous the material, the better the safety performance required of the package. The IAEA Transport Regulations set out safety criteria for nine different types of packages designated as: Excepted package; Industrial Packages Type IP-1, Type IP-2, and Type IP-3; and Type A, Type B(U), Type B(M), Type C packages and packages containing uranium hexafluoride [8, Section VI]. Criteria are defined for the design of these packages according to both the activity and the physical form of the radioactive material they may contain. The IAEA Transport Regulations require demonstration of the ability of transport packages to withstand certain physical challenges that increase in severity as the hazard of the radioactive content of the package increases (see Section 4.3.3).

The IAEA Transport Regulations also address packing, labelling, loading, storage, in-transit storage, testing requirements and impose limits on external radiation and surface contamination. They impose additional requirements for packages containing fissile material. Quality assurance requirements are specified for all stages in the life of a package, from design and manufacture to operation and maintenance. The IAEA Transport Regulations are multi-modal in that they apply to the transport of radioactive materials by any mode.

The IAEA Transport Regulations are supported by a number of Safety Guides of an advisory and explanatory nature. These were developed by the IAEA to advise on and facilitate the implementation and application of the IAEA Transport Regulations, and to improve the understanding of the regulatory provisions and requirements. These documents include the following:

- Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (SSG-26) [25]
- Planning and Preparing for Emergency Response to Transport Accidents involving Radioactive Materials (TS-G-1.2) [26]
- Radiation Protection Programmes for the Transport of Radioactive Material (TS-G-1.3) [27]

4.2 Package design approval

As noted in Section 4 above, one of the key elements in the IAEA Transport Regulations underpinning safety is the requirement that an assessment of compliance with the IAEA Transport Regulations is undertaken by a competent authority. In undertaking this

assessment the competent authority monitors all aspects of radioactive materials transport including package design, manufacture, maintenance and use. The IAEA Transport Regulations specifically require that a competent authority approves certain package designs. Such packages are those containing the higher hazard radioactive inventories, that is Types B(U), B(M) and C packages as well as those containing fissile material. Package designs for lower hazard packages are Industrial Packages Type IP-1, Type IP-2 and Type IP-3, and Type A packages, and these do not require competent authority approval; instead their designs may be approved by an independent body or self-approved by the design authority. However, documentary evidence of compliance of these designs with the applicable requirements is to be made available to the competent authority on request. In either case, approval is granted after a thorough assessment of the design has shown it to be compliant with requirements. A competent authority will issue a CoA and a self-approving body will issue a document that serves the same purpose.

The CoA or equivalent documentary evidence of approval will [8, Section VIII]:

- provide evidence of approval for the use of the design
- state the issue date and expiry date
- include a specification of the authorised radioactive contents, including the physical and chemical forms, the activities of the various isotopes and the permissible amount of fissile material
- include a detailed listing of any supplementary controls required for the preparation, loading, carriage, unloading and handling of the consignment
- include a specification of the applicable quality assurance programme

The CoA or equivalent document is valid for a certain period, typically three to five years, after which it may be renewed by an application supported by the submission of a reviewed DSR.

4.3 Design safety report

For package designs that require competent authority approval, submission of a DSR is a mandatory step in the approval process. For package designs not requiring competent authority approval European guidance [28] proposes that the same discipline of approach is adopted, with the scope and technical content of the DSR set at the appropriate levels to demonstrate compliance with the regulatory requirements.

For a particular transport package design, the DSR contains:

- a detailed specification of the transport package, including if separate, the waste container and its permissible contents (including a criticality safety assessment)
- the results of tests and analyses against a range of performance criteria
- instructions for handling and maintenance of the package
- the quality assurance arrangements for all aspects of transport

The ONR has published guidance [29] first issued by the Radioactive Materials Transport Division of the Department of the Environment, Transport and the Regions (commonly known as the DETR Applicants' Guide) to provide assistance in the preparation of a DSR. This guide covers all package designs whether competent authority approval is required or not. It is based on the IAEA Transport Regulations and for each package type sets out a structure and minimum content for a DSR to enable the applicant to demonstrate compliance.

When a DSR is submitted to a competent authority for approval, it is subject to a thorough assessment and allows competent authority assessors to raise a series of questions about the transport container design and contents. In many cases, queries arise from a need to provide a degree of clarification, but in some instances it may be necessary to carry out

additional analyses to provide further justification for the performance of the transport package. An assessor may choose to carry out independent analyses to validate a particular aspect of the package performance, and it may be necessary for the applicant to modify the DSR to take account of that assessment before approval can be granted.

RWM will be required to produce DSRs for the transport containers for which it is the design authority. The SWTC-285 [22] is the transport container whose design is most advanced and elements of the DSR for its use with different types of waste package have already been produced to support RWM's design and assessment work. DSRs for the SWTC-70 [22] and the SWTC-150 [22] are also being produced. Ultimately, RWM will produce a DSR for each transport and waste package combination, for which it is the design authority, covering all wastestreams likely to be packaged within. In preparing these DSRs, the guidance given in the 'DETR Applicants' Guide' will be followed.

RWM has embarked on some aspects of the DSR for the Disposal Container Transport Containers (DCTC), however, the DCTC is currently at an early stage of the design and this work is not planned to be completed for several years.

Certain element of DSRs have been prepared by RWM for both the 4 metre and 2 metre box transport packages in order to support RWM's disposability advice to waste packagers. However, RWM is not the Design Authority for these transport containers; waste packagers have developed a number of variants, and hence it is those waste packagers or their suppliers that are the design authorities.

DSRs have been, or will be, produced by other design authorities for waste container and transport container designs. Examples of these containers include the 6 metre cube concrete box, the 1 cubic metre and 500 litre concrete drums, the 500 litre robust shielded drum and the 3 cubic metre robust shielded box. All these are described in the Generic Transport System Design [22].

4.3.1 Transport package contents specification

A key requirement of a DSR is to evaluate the performance of the transport container design against criteria set out in the IAEA Transport Regulations [8, Section VI] and define acceptable limits on the contents. This entails setting limits on the total quantity of activity in the transport package as well as limits relating to the effects of activity such as heat output, radionuclide limits and fissile material controls. DSRs also include restraints on the physical and chemical content characteristics such as the presence of materials that could present non-radiological hazards (for example toxic, flammable and biological hazards), and the potential for gas generation that could lead to pressurisation of the transport package or the creation of toxic or flammable mixtures during the transport operation.

An important component of a DSR is therefore the contents specification document for the package to which it applies. The purpose of a contents specification document is to define numerical limits on the transport package radionuclide inventory, for the full range of radionuclides expected to be present in the waste, as set out in the IAEA Transport Regulations. In the case of the SWTC, as a Type-B package, the limits are set on the basis of:

- total activity
- radiogenic heat generation
- external radiation dose rate
- radioactive gas generation
- activity released under normal and accident conditions of transport
- criticality safety

As described in Section 5, RWM's Disposability Assessment process [10] provides assurance to waste packagers that the wastes once packaged will be compatible with the

currently envisaged plans for transport and disposal. To support this process, RWM has produced a range of generic waste package specifications [30]. These specifications define generic standards and performance requirements for waste packages and provide a baseline that waste packagers can use to determine how to package waste and meet the requirements for passive safety and compatibility with the requirements for transport and disposal. Contents specification documents underpin these generic waste package specifications and RWM has prepared, or is in the process of preparing, contents specification documents for all RWM's LHGW transport packages [22].

RWM has prepared contents specification documents for the following transport packages:

- 500 litre drum waste packages and 500 litre drum waste packages for annular grouted waste transported in an SWTC-70 transport container [31]
- 500 litre drum waste packages and 500 litre drum waste packages for annular grouted waste transported in an SWTC-285 transport container [32]
- 3 cubic metre drum transported in an SWTC-70 transport container [33]
- 3 cubic metre drum transported in an SWTC-285 transport container [34]
- corner-lifting variant of 3 cubic metre box transported in an SWTC-70 transport container [35]
- corner-lifting variant of 3 cubic metre box transported in an SWTC-285 transport container [36]
- side lifting variant of 3 cubic metre box transported in an SWTC-70 transport container [37]
- side lifting variant of 3 cubic metre box transported in an SWTC-285 transport container [38]
- 2 metre box [39][2]
- 4 metre box [40][2]
- miscellaneous beta gamma waste store box package in an SWTC-150 transport container [41]

These contents specification documents covered all the waste streams likely to be carried in the respective transport package at the time of writing. RWM will however continue to develop contents specifications for packages such as the 500 litre robust shielded drum in an SWTC-150 and the DV-70 in a TDC, as and when required.

In future years when the design is more advanced, RWM will prepare contents specification documents for disposal containers containing HLW, SF, plutonium and highly enriched uranium, which will be transported in a DCTC.

Contents specification documents are maintained and updated as required as enhanced information becomes available, for example through:

- learning/feedback from the Disposability Assessment process
- changes or improvements in the knowledge base, good practice in the wider radioactive material transport community and regulatory requirements
- a review of the seal performance data for the SWTC family of transport package designs
- a review of the 'multilateral approval'[3] assumptions for the SWTC family of transport

2 RWM is not the Design Authority for the 2 and 4 metre box, but RWM has prepared provisional Contents Specification Documents for these transport packages to support disposability assessment advice.

package designs

One possible outcome of a disposability assessment is that a packaging proposal fails the check of compliance with the contents specification document. Usually in this case, the packaging proposal would need to be revised and resubmitted with compliant contents. However, it may be appropriate that some aspect of the disposal system, for example the design of the transport container, could be changed to accommodate the proposed waste packages. In either case, the fundamental requirement is that the transport package will meet the requirements of the IAEA Transport Regulations.

4.3.2 Criticality safety assessment

Specific requirements for the safe transport of packages containing fissile material are given in the IAEA Transport Regulations. These state that fissile material must be transported so as to remain sub-critical and that consideration must be given to the effects of:

- water leaking into or out of the transport packages
- the loss of efficiency of built-in neutron absorbers or moderators
- rearrangement of the contents either within the package or as a result of loss from the package
- reduction of spaces within or between transport packages
- packages becoming immersed in water
- accumulation of packages
- temperature changes

Limits derived from these requirements, for example on the material composition or configuration of the material that can be carried in a transport package, are set out in criticality safety assessments which, like contents specification documents, underpin the generic waste package specifications and support RWM's Disposability Assessment process.

For waste packages containing fissile material, RWM is developing and maintaining a suite of criticality safety assessments, their underpinning methodologies and some supporting data or information. This includes development of criticality safety assessments for the SWTC family of transport package designs.

Other relevant work in this area includes the development of a concept design and criticality safety assessment for a DCTC [22] incorporating multiple water barrier features[4] to ensure criticality safety. The use of such features is novel in the UK and further work is underway to demonstrate that the concept design is feasible. In addition, ongoing studies on disposal concept options for plutonium and uranium will lead to the production of a criticality safety assessment for the transport of those materials.

The IAEA Transport Regulations make allowance for materials that contain fissile nuclides but do not present a criticality hazard owing to the limited quantity or concentration of fissile

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3 Multilateral approval applies to shipments that pass through more than one country and means approval by the competent authority of the country of origin and of any other countries through or into which the shipment will be transported. A full definition is given in the IAEA Transport Regulations.

4 More generally, wastestreams representing a criticality safety challenge could in principle be transported using multiple water barriers. Alternatively, or in addition, the load would need to be divided.

nuclides present. These materials are excepted from classification as fissile. The arrangements for transport packages containing fissile excepted material are covered in Section 4.5.

4.3.3 Testing and test results

As explained in previous sections, compliance must be demonstrated against the requirements of the IAEA Transport Regulations relating to the design of a transport package according to the activity and physical form of the radioactive material. A requirement of the DSR is to demonstrate that a transport package will be compliant with the mechanical and thermal performance required to ensure the safe transport of the radioactive content. The IAEA Transport Regulations require demonstration of the ability of the transport packages to withstand certain physical challenges that increase in severity as the hazard of the radioactive content of the package increases. These tests aim to simulate the normal transport operations and accident conditions of transport.

Tests conducted to simulate normal transport conditions consist of drops of up to 1.2 metres, a penetration test in which a bar is dropped 1 metre onto the package, stack testing, and tests to withstand water spray, acceleration, vibration and temperature variation.

Typical tests that simulate accident conditions include a drop test, punch test, fire test and water immersion test.

The variety of mechanical tests consider a large range of accidents which could expose packages to severe dynamic forces and impose damage on the package equivalent to that which would be observed if the package were involved in a severe accident. For Type B and fissile transport packages these tests cover impacts with a flat unyielding surface and with a cylindrical punch. The surface impact test requires a 9 metre drop onto a defined unyielding surface and punch impact requires a 1 metre drop onto a rigid bar. Both tests require a package drop orientation such that the package suffers maximum damage. In a real transport accident, targets such as soil or other vehicles would absorb part of the impact energy. Only the most extreme accident could lead to an impact as severe as the test conditions.

The thermal tests for Type B and Fissile transport packages are sufficiently severe to encompass transport related accidents involving fires. Test conditions are based on a fully engulfing fire that burns at an average temperature of at least 800°C for 30 minutes duration [8, Section VII]. Other parameters relating to fire size, shape and heat transfer characteristics are also specified in order to define the fire conditions that the package is required to withstand.

As a simulation of a transport accident near or on a river, lake or port, the immersion test for Type B and fissile transport packages simulates immersion in 15 metres of water for eight hours. To address immersion in deep water, a further immersion test equivalent to immersion in 200 metres of water for 1 hour is required for higher hazard (Type B) packages. The duration of immersion is intended to be sufficient for the package to come to a steady state when, for example, flooding of any accessible compartments would be complete. The designs of the SWTC and DCTC will need to meet the requirements of this enhanced immersion test, and satisfaction of this requirement has yet to be substantiated.

These tests are conducted in such a way as to simulate a sequence of damage to the package in a real accident, that is mechanical impacts followed by thermal exposure. The test sequences ensure mechanical damage to the package has taken place before the imposition of the thermal test in order to maximise the potential for damage to the transport package.

Demonstration of compliance with the specified performance criteria can be by means of tests and calculations or reasoned arguments and this demonstration of compliance may be included in the DSR.

A number of mechanical tests for the SWTC-285 have been undertaken. In addition, RWM has carried out computer modelling, including finite element analyses, and has identified a programme of further tests and analyses. The results of these tests and analyses will form part of the DSR for the SWTC-285.

There are no accident performance criteria for IP transport packages, since the consequences of an accidental release are limited by constraints on the contents.

4.3.4 Transport package operation and maintenance

A DSR will also include details of the operation and maintenance of the transport package, including:

- the inspection and checks to be undertaken before each shipment
- handling and tie-down requirements
- loading and unloading of the transport package contents
- assembly of the packaging components
- any supplementary equipment and operational controls to be applied during transport which are needed to ensure that the transport package meets the regulatory requirements for transport
- the maintenance and inspection requirements for each shipment, before departure, and during turnaround
- arrangements for periodic inspection to monitor wear and tear and identify any deterioration in components during transport

These details will be reflected in the resulting CoA or equivalent documentary evidence of approval.

A consignor must comply with the operating and handling instructions to ensure that the waste package is loaded and handled safely without damage and remains compliant with the requirements of the CoA or equivalent document.

Inspection and maintenance documents will cover the turnaround process and periodic maintenance. A receipt and despatch inspection and maintenance quality plan is required and this will list all requirements with which a consignor must comply in order to ensure that the transport packages can be handled safely and in accordance with the requirements of the IAEA Transport Regulations.

It is anticipated that there will be a number of organisations involved in the transport operation. Each operator will develop procedures and local work instructions to operate their own consignments in accordance with the DSR and CoA or equivalent document.

4.3.5 Quality management system

The IAEA Transport Regulations require all activities associated with the transport of a package to be carried out within a management system based on international, national or other standards acceptable to the relevant competent authority. This must cover arrangements for the design, manufacture, documentation, use, maintenance and inspection of all transport packages and for their transport and in-transit handling operations. All organisations, including RWM, that undertake such activities must therefore have a management system to meet the requirements for the IAEA Transport Regulations for the activities that they undertake. The management system will be extended to cover other functions as appropriate in the future.

RWM requires that waste packagers implement and maintain a management system with the objective of assuring the quality of both the waste package and the associated data and information [42]. This management system will apply to all activities that could affect the quality of the waste package including:

- waste characterisation
- waste container design
- waste container manufacture
- wasteform development
- process development
- plant specification and design
- Letter of Compliance submissions and action points (the Disposability Assessment process is described in Section 5)
- plant commissioning and operation
- raw materials storage
- waste package production
- waste package interim storage and monitoring
- control of non-conforming packages
- change control and continual improvement of waste package design processing plant and interim storage
- waste package records and their long-term management and retention

Waste packagers are also required by RWM to produce a waste product specification (WPrS) for a waste package. This defines the waste, waste container, conditioning materials, wasteform formulation, process conditions, storage conditions and all relevant research and development for each waste package type. Waste processing and packaging plants, as well as waste assay and package monitoring equipment designs, are being developed to produce compliant waste packages.

Waste packagers must demonstrate to RWM that the management system applies to all stages of the waste management process, including the disposability assessment process, and that the waste is packaged in accordance with the management system and the WPrS. RWM (or the agreed agents) may undertake audits of activities that affect the quality of waste packages.

Guidance has been prepared [43] on the waste package data and information which the waste packagers must record. The guidance specifies that:

- data shall be recorded for each waste package
- each waste package shall be readily identifiable and shall be linked to data recorded about that package, and also to the WPrS against which it was produced
- the recorded data shall:
    - facilitate tracking of the location and status of each waste package at all times
    - provide verification of conformance of a waste package with the relevant endorsement for disposability and WPrS, or identify areas of non-conformance
    - enable demonstration of conformance with the IAEA Transport Regulations (as implemented in UK Legislation)
    - enable demonstration of conformance with the WAC for disposal
    - facilitate provision of the disposal record

4.4 Radiation protection

The IAEA Transport Regulations impose a regulatory requirement for an RPP covering the transport of radioactive material. The purpose of the RPP, as given by the IAEA, is to establish and document in a systematic and structured way the framework of controls applied to satisfy the radiation protection requirements of the IAEA Transport Regulations, that is to limit both normal and potential exposures of workers and members of the public. RPPs thus define the radiation protection objectives of a transport organisation and describe the operator's practical measures to meet these objectives.

RPPs are required to cover all activities of transport, and these are carried out by different parties over the course of a transport operation. The parties involved in transport may include consignors, carriers, transhipment workers, and consignees. Until the holders of the various roles are identified, RWM is assuming responsibility for all aspects of the transport operation.

RPPs are required to be in place before transport operations can begin; there is no regulatory requirement for them before then. However, RPPs will be developed by RWM during the design phase, the controls identified in developing RPPs will then be used to help develop WAC.

An RPP will cover all aspects of transport but the main emphasis will be on the stages of transport operations giving rise to exposure to radiation. The principal radiation protection considerations of an RPP include:

- scope of the RPP
- roles and responsibilities
- dose assessment
- dose limits, constraints, optimisation
- surface contamination
- segregation and other protective measures
- emergency response
- training
- management systems

Prior dose assessment is the fundamental starting point for an RPP and IAEA guidance [44] suggests a graded approach to the controls required based on the magnitude of the likely radiation exposure [44, Table 1]. The prior dose assessment forms the basis for the degree of controls that are required to ensure the radiation protection of the workers. The generic TSA reports on bounding and best estimate dose assessments [4, Section 5] in order to inform development of the disposal system. A site-specific best estimate dose assessment will be carried out once a site for the GDF has been identified, and it is anticipated that this will provide a suitable basis for the prior dose assessment. The generic TSA is a generic assessment of doses to workers that can be used to inform optimisation of the transport system design.

4.5 Fissile exception design

The arrangements for transport packages containing fissile material are covered in Section 4.3.2. However, the IAEA Transport Regulations make allowance for materials that contain fissile nuclides but that do not present a criticality owing to the limited quantity or concentration of fissile nuclides present to be defined as non-fissile, or excepted from classification as fissile. Criteria for these classifications are defined within the IAEA Transport Regulations [8, Section II, Section IV]. Historically, some of these criteria applied to the material alone, for example, the uranium enrichment level, and some were dependent on the package or consignment, for example the fissile mass per package or

consignment. Such material would then be excepted from the requirements for the transport of fissile material, notably controls on the design and approval of transport packaging for criticality safety, package accumulation control and the need for additional criticality safety assessment.

The 2012 edition of the IAEA Transport Regulations introduced the possibility for a material design to be fissile-excepted [8, Section IV]. Thus, an application can be made for a material, rather than a package. If a material design is to be approved as fissile-excepted, it must be demonstrated by the applicant to remain subcritical without the need for accumulation control. This requires either that the material remains subcritical in an unlimited quantity or that the quantity of material required to form a critical arrangement could not credibly accumulate during transport. The material must remain subcritical under the equivalent conditions as specified in the IAEA Transport Regulations for fissile packages.

This allowance is applicable to a broad range of radioactive waste material types. It presents a significant opportunity to demonstrate the criticality safety of a range of waste materials that may be transported in a range of package designs through a single fissile exception approval.

To that end, RWM has submitted an application [45] to the ONR for approval of waste materials containing a low concentration of fissile nuclides as fissile excepted. RWM's approach in producing an application is to justify the safety of a range of low heat generating wastes through a high-level specification that covers as broad a range of wastes as possible. Hence rather than being specific to a particular waste type, the fissile exception is based upon generic requirements that could be met by a range of waste types and by a range of waste packaging approaches.

The application consists of a specification of the material demonstrated to be safe and a demonstration that the material will remain safely sub-critical in routine, normal and accident conditions of transport. If successful, the application could be invoked by waste packagers to demonstrate the transport criticality safety of a broad range of wastes.

5 The Disposability Assessment Process

At this stage in the development of the disposal system, some waste packages have already been manufactured and placed in store awaiting transport to the GDF. In addition, waste packagers need to make plans for manufacture and storage of packages for future waste arisings. Compliance of these packages with RWM's transport and disposal requirements, and regulatory requirements, is assessed through RWM's Disposability Assessment process [10]. This process gives confidence to waste packagers that proposed packages will comply with the eventual needs for transport and disposal, and confidence to RWM that the disposal system considered within the DSSC will be appropriate to the wastes it will be expected to provide for.

Waste packagers apply to RWM for a Letter of Compliance (LoC) through the Disposability Assessment process for legacy wastes and future waste arisings. These include wastes and materials from existing nuclear power stations, from the associated production and reprocessing of fuel, from the use of radioactive materials in industry, medicine and research, and from defence-related nuclear programmes. Arisings from a new build programme are considered separately by provision of packaging advice by RWM through its generic design assessment Disposability Assessment process.

The main purposes of the Disposability Assessment process, as currently constituted, are to:

- give confidence to waste packagers that the implementation of their proposals for the packaging of waste will result in waste packages that would be compliant with the eventual needs for transport to and disposal in the GDF
- ensure that packaging strategies, and ultimately investment decisions by waste packagers, are soundly based and will result in waste package designs that best meet the needs for processing and storage as well as disposal
- provide RWM with assurance that the geological disposal concepts considered within the generic DSSC will be appropriate for the wastes they will be expected to cover
- permit the identification of wastes that could challenge current disposal concepts and allow early consideration of what changes may be required to those concepts to permit the wastes to be accommodated

These objectives are achieved by the waste packagers working to RWM's packaging standards [30, 46, 47] and seeking input from RWM through the Disposability Assessment process.

Within the Disposability Assessment process, compliance of proposed waste packages with elements of the DSR is assessed. The applicable DSR elements are the contents specification documents and criticality safety assessments.

For packages where RWM is the Design Authority (as is the case for the SWTC) there is direct access to the design process and knowledge of the contents specification document and, in the case where the package contains fissile material, the Criticality Safety Assessment. Hence, the process of determining whether the proposed waste packages are likely to be transportable at the appropriate time is straightforward. If a proposal is not compliant, RWM has the design knowledge to determine whether a modification to the design or the contents specification document is feasible. Packaging proposals that are out of specification may be endorsed at earlier stages in the Disposability Assessment process on condition that the contents specification document is revised to allow acceptance of that waste by the final stage.

Where RWM is not the Design Authority (as in the case for the 6 metre cube concrete box) packaging proposals will be assessed against the CoA or equivalent document, or any

contents specification document provided. RWM will check and advise whether the proposal is within specification. If a waste packaging proposal is not compliant, RWM will not have access to the safety basis of the design and so in case of uncertainty must defer questions to the Design Authority. RWM will advise the waste packagers of this finding, explaining the rationale and refer the applicant to the design authority for further advice and design changes if necessary.

5.1 Submission of a waste packaging proposal

A waste packager assembles a submission for a waste packaging proposal for assessment by RWM. Where waste already exists, the submission describes the nature of the wastes and plans for retrieval, characterisation and assay, the conditioning process proposed and the form of the proposed waste package. Waste packagers are encouraged to seek engagement through this process before wastes are produced, to give confidence that the wastes will ultimately be suitable for transport and disposal. In such cases, information is likely to be at a less detailed level and will be assessed in stages as more information becomes available.

5.2 Assessment

The Disposability Assessment process is described at a high level in the Technical Background [3, Section 3.4] and in greater depth in RWM's Waste Packages and the Assessment of their Disposability [48]. The assessment process, as it applies to transport, is summarised here.

In general, a disposability assessment comprises two distinct components:

- Establishing a good understanding of the properties of the proposed waste packages. This is achieved by a series of technical evaluations, which establish that the characteristics of the waste package are understood in sufficient detail.
- Comparing the performance of the packaged waste against the concept safety assessments for transport, operational and post-closure. For transport, this means a comparison with the generic TSA.

As far as transport safety is concerned, the assessment begins with a check to confirm compliance with the limits specified in the IAEA Transport Regulations. As discussed earlier, for each transport package, the contents specification documents and Criticality Safety Assessments, which will form part of the DSR, define numerical limits on the permissible radioactive and fissile contents for the full range of radionuclides expected to be present in the waste. These contents limits are derived from the various transport package limits (surface temperature, external dose rate, internal gas pressure etc) set out in the IAEA Transport Regulations.

A hierarchy of waste package specifications developed by RWM define the standard properties and performance requirements for waste packages that are compatible with the anticipated regulations, systems and safety cases for transport to and disposal. Checking for compliance with the waste packaging specifications is an important step of the Disposability Assessment process.

To aid the assessment of waste packaging submissions and the compliance check against the limits in the Contents Specifications Documents and Criticality Safety Assessments, two specialist toolkits have been developed. They provide information on likely compliance with the general and fissile requirements of the IAEA Transport Regulations. The toolkits are:

- Transport Operational Container Assessment Tool (TOpCAT), used to check compliance with the relevant contents specifications

- Criticality Contents Assessment Tool (CritiCAT), used to assess the criticality element of submissions

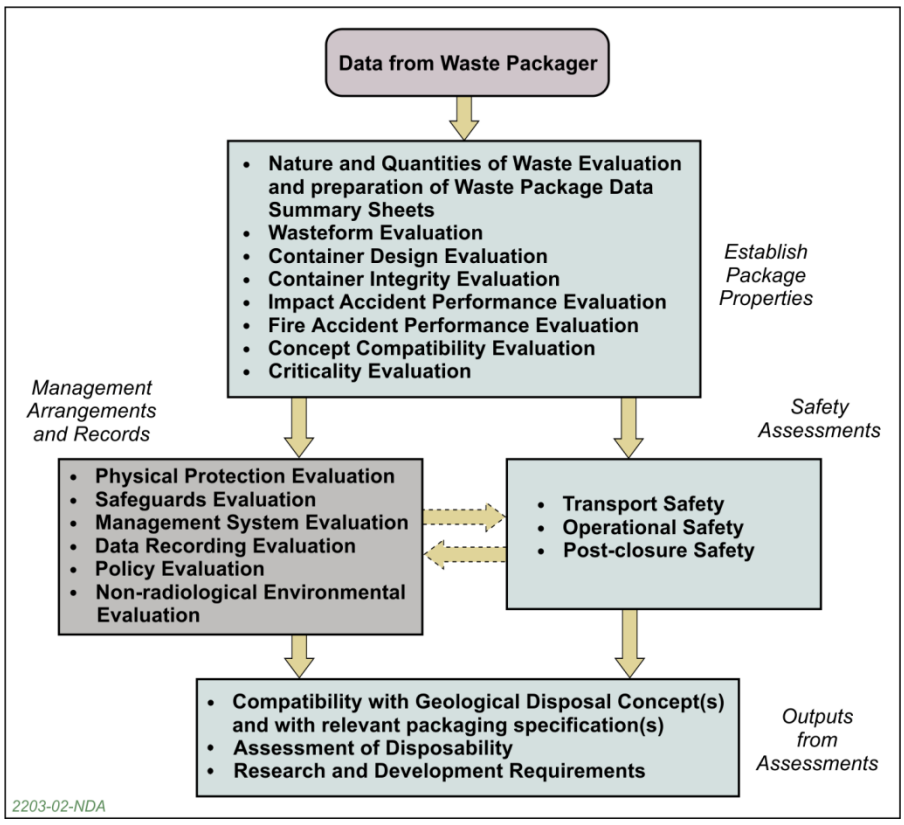
Typical checks include confirmation that the predicted heat output and potential pressurisation are within limits, and that the criteria for transporting fissile material will be met. In addition, the software toolkit can assess whether the amount of shielding for a given transport container variant is sufficient.

Following compliance checks, a check is performed against compatibility with the transport (and also operational and environmental) assessments as presented in the generic DSSC. Although not a regulatory requirement, this stage is important as it enables RWM to understand the effect of the waste packaging proposal on the transport safety case. This check also builds confidence in the assessment basis because the packaging proposals represent the most up to date information on packaging assumptions. The proposal is compared with the following assessments:

- the generic TSA [4]
- the generic OSC [49]
- the generic ESC [50]

The assessment process is shown diagrammatically in Figure 4.

Figure 4 Outline of a Disposability Assessment



RWM presents its response to the submission of a waste packaging proposal in an assessment report, which sets out the case for transport and disposability by summarising and drawing together the assessments undertaken and RWM's findings. This assessment of disposability is intended to show, in a transparent and visible way, the conclusions on whether the packaging proposal is compliant with packaging standards and specifications. It also indicates how the proposal impacts on existing transport, operational and environmental assessments.

Where appropriate, the report will be accompanied by an LoC signifying that the proposed waste package is compliant with RWM's packaging standards and the underlying geological disposal concept.

5.3 LoC application and review

Waste packages may be required to reside in interim storage for an extended period before transport and ultimate disposal, so it is important that the LoC and associated disposability assessment is kept up to date. A periodic review process has been developed so that the disposability case and LoC can be revisited and updated on a notional ten year cycle [51]. This means that the LoC and its associated records are kept 'live'. The objective of the review is to give confidence to all stakeholders that the LoC is kept up to date and hence that the waste package remains suitable for transport and disposal against the latest requirements and safety cases.

6 Pre-despatch Activities

When the GDF has been constructed and licensed to receive waste, a programme for the emptying of interim stores will commence. It will be necessary to confirm that waste packages meet the requirements of both the CoA or equivalent document, which sets out the requirements for transport, and the WAC which set out the requirements for disposability.

This is particularly important for waste packages that have spent up to several decades in interim surface storage and checks to confirm that the packages have not experienced untoward ageing will be undertaken. Furthermore, the criteria against which transportability and disposability are assessed may have evolved, particularly once the GDF site is known and licensed. It is therefore important that measures are in place to confirm that waste packages that have been in extended storage still meet the requirements for transport and disposability.

A package record will be maintained that documents the physical monitoring that takes place during the storage phase and the trail of initial and periodic assessments against transport and disposal criteria.

This section describes:

- the processes in place to monitor package condition during storage and provide assurance that the package remains compliant with the requirements of the CoA or equivalent document
- the package record and its role in ensuring compliance with transport criteria and WAC

6.1 Package evolution during storage

Following manufacture, waste packages may spend up to several decades in interim surface storage prior to transport to the GDF. Waste package condition may evolve during this time and so to control and monitor this, the following processes and requirements are, or will be in place:

- the Disposability Assessment process takes into consideration:
  - an assessment of the predicted evolution of the package
  - an assessment of how transport safety could potentially be affected by possible ageing mechanisms affecting waste package performance
- a process whereby requirements for waste packages are informed by the disposability assessment of those waste packages, in particular:
  - the waste package design, and its evolution in storage
  - maintenance and monitoring of the store environment
  - monitoring of the condition of the waste packages during storage
- requirements that higher hazard wastes are either:
  - transported in a transport container: this will be manufactured closer to the time of transport and therefore not subject to extended storage, or
  - packaged in multi-purpose containers, which are specifically designed to be suitable for long term storage, transport and disposal

The status of RWM's research on package evolution is given in a research status report [52] on that topic.

RWM has produced guidance on the control of the environmental conditions during interim surface storage [53] and on the waste package monitoring regimes that should be instituted during such storage [54].

For waste packages which are more than 10 years old, it is anticipated that the process for the periodic review of LoC endorsement would include a review of the waste package monitoring arrangements and a consideration of the consequences of any package evolution that this monitoring has identified.

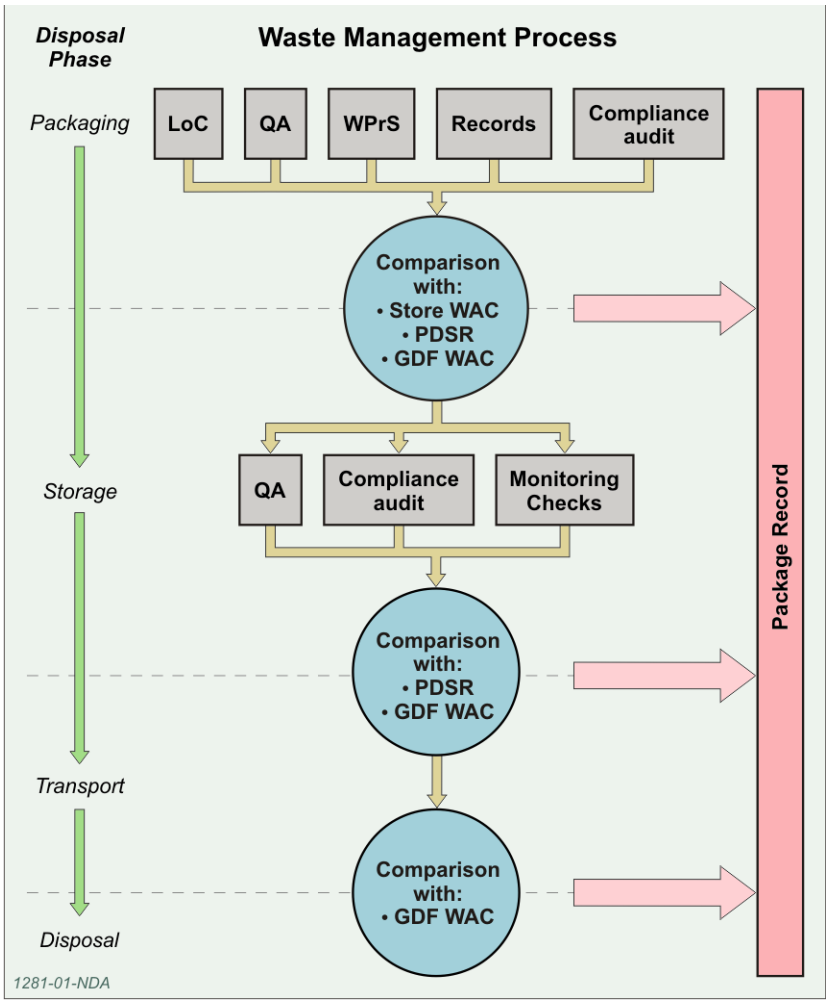
6.2 Package record

The condition of the waste packages will be assessed prior to retrieval by review of the package record. Waste packagers are required to establish a data recording system for acquiring, recording and managing information for each waste package. These records include the WPrS, the LoC, manufacturing records, store records and package inspection records. Collectively these records, and the means by which they are collated and logged, are referred to as the package record [10].

Figure 5 summarises the role of the package record, the key requirement of which is to demonstrate that the waste package has been manufactured and stored in accordance with the terms of the LoC endorsement. The package record plays an important part in supporting the safety cases for interim storage, transport to the GDF, emplacement operations at the GDF and finally for the ultimate post-closure period of the GDF. The package record will also play an essential role in demonstrating compliance of the waste package with the conditions for transport and the GDF WAC.

The package record will accompany the waste package as it proceeds through the different phases of waste management and will be updated as appropriate to demonstrate compliance with the various safety cases.

Figure 5 Role of the package record



6.2.1 Compliance of waste packages with the needs of transport

The package record will demonstrate compliance by providing a history of compliance checks, backed up by physical measurements (of dose rate, heat emission and non-fixed surface contamination for example) and visual examination of the waste packages at various points.

An approved DSR is not required during storage, however certain elements of the DSR, most notably the contents specification document and any technical analysis necessary to underpin the limits set out therein, will be required prior to transport in order to underpin the Disposability Assessment process. It is these elements of the DSR against which compliance of the package is checked and recorded in the package record.

Where a CoA or equivalent document has been issued, it is necessary for the DSR to be kept up to date to support renewal applications and to demonstrate their continued validity. The DETR Applicants' Guide [29] explains that before applying for a second renewal, the design authority must have subjected the DSR and all supporting evidence to a Design Review. A Design Review considers advances in calculation techniques, availability of more accurate physical property data, changes in the design, package usage, operational experience and the maintenance and inspection history.

6.2.2 Compliance of waste packages with the GDF WAC

The package record will also record compliance checks with WAC. RWM plans to produce WAC following the identification of a site and definition of the design for the GDF. The present waste package specifications act as preliminary WAC and take into account the regulatory and safety case requirements imposed for both transport and disposal. It is expected that as plans for the implementation of the GDF become more defined and notably more site-specific, the specifications would evolve into WAC for an operational GDF.

RWM anticipates that the WAC will have two strands:

- limits on the nature and quantity of the contents of waste packages; in particular their radioactive inventory, to ensure compliance with the safety case for transport and disposal
- physical requirements and limitations of the waste package derived from the needs of the GDF, such as dimensions, handling features, stacking ability and accident performance

Once the WAC are defined, the disposability assessment against the generic waste package specifications will be replaced with an assessment against the WAC. Stored packages assessed against generic waste package specifications will be reassessed against WAC, in addition to the assessment against the CoA or equivalent document, as part of the periodic review process, and this process will be recorded in the package record.

7 Summary

This report has outlined the principles and processes in place for the safe transport of radioactive materials, in particular the package approval process as it is applied to the transport of radioactive wastes.

Safe transport of radioactive material is assured in the UK by compliance with UK regulations that implement the IAEA Transport Regulations. The IAEA Transport Regulations specify criteria that must be met by each transport package, for example, on external dose rate and surface temperature. The regulations also require demonstration that transport package designs can withstand certain physical challenges, and satisfy other tests that simulate their performance under normal conditions and in accidents. Additionally, the regulations allow for designs of materials that contribute to safety, for example by maintaining sub-criticality.

Responsibility for gaining approval for transport package and material designs lies with the Design Authority, which usually discharges this responsibility by producing a Design Safety Report (DSR) which includes all the information required to demonstrate the safety of the package and which establishes clear limits on contents that are required to meet key package safety parameters, such as dose rate, activity and form of contents and limits on fissile contents.

For certain package or material designs, that is, those pertaining to higher hazard radioactive materials, the DSR is submitted to a competent authority for approval. The legal competent authority in the UK for transport of civil waste is currently the Office for Nuclear Regulation. The legal competent authority for transport of defence waste is the Secretary of State for Defence (with the DNSR acting as the regulator). For other designs, that is those pertaining to lower hazard radioactive materials, self-approval by the Design Authority is sufficient, and is subject to audit by the competent authority.

In order to demonstrate approval, all material and package designs must have associated documentary evidence of the compliance of the design with defined requirements. A competent authority will issue a Certificate of Approval (CoA) when approval is granted, and bodies undertaking self-approval maintain evidence, usually in the form of a CoA.

At this early stage in the development of the geological disposal system, packaging operations are already underway at the waste producing sites and some waste packages have already been manufactured and placed in interim storage awaiting transport to the GDF. In addition, waste packagers need to make plans for manufacture and storage of packages for future waste arisings. RWM supports this by developing its generic transport system design which includes transport containers for waste packages. RWM produces elements of the DSRs necessary for its transport containers so that it can define contents specifications.

Compliance of proposed waste packages with regulations and RWM's own requirements for transport and disposal is assessed as part of RWM's Disposability Assessment process. This process allows waste packaging to proceed with confidence that packages will be suitable for transport and disposal. This gives RWM confidence that the packaging solutions in its design will cover the inventory for disposal.

RWM expects that any waste package made now will be periodically reviewed and will have a detailed history, including waste conditioning and storage records. It is expected that such packages will be compliant with a future CoA and will therefore be acceptable for transport to the GDF. It will be necessary to confirm this acceptability prior to despatch.

Following confirmation of the suitability for transport, the waste package will be retrieved from storage, checked to confirm that it meets RWM's waste acceptance criteria and the requirements of the CoA or equivalent and loaded into a transport container where

applicable. The whole transport package can then be loaded onto the transport conveyance and cleared for despatch. These activities will be specified in detailed procedures and local work instructions prepared by the consignor to meet the requirements set out in the CoA.

Confidence that transport packages appropriate to the full range of wastes in the inventory can be made is based on a long history and experience of radioactive material transport, with packages having been produced for many different wastes and backed up by the Disposability Assessment process, as described above.

In addition to the package design requirements, transport safety is enhanced by assigning appropriate responsibilities to all transport operators, including the consignor, carrier and consignee. The IAEA Transport Regulations specify requirements for appropriate administrative and operational controls, quality assurance, training and expertise, security and emergency provisions and accident reporting. Waste packagers are required to implement and maintain a management system with the objective of assuring the quality of both the waste package and the associated data records.

Within the transport operations themselves, doses are kept ALARP by production of and adherence to controls set out in an RPP.

In conclusion, a robust set of processes and procedures are in place to assure the safe transport of a package containing radioactive waste, from the waste arising sites to a GDF, including the safety of all in-transit handling operations.

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Glossary

A glossary of terms specific to the generic DSSC can be found in the Technical Background.

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