The management of higher activity radioactive waste on nuclear licensed sites

Part 3b
Conditioning and disposability

Joint guidance from the Office for Nuclear Regulation, the Environment Agency and the Scottish Environment Protection Agency to nuclear licensees

November 2011

Contents

Foreword

The Office for Nuclear Regulation (ONR), the Environment Agency and the Scottish Environment Protection Agency (SEPA) (together referred to as 'the regulators') have issued this guidance jointly.

Dutyholders on nuclear licensed sites who follow this guidance will normally be doing enough to comply with the relevant law as interpreted by the regulators at the time of writing, and the regulators may refer to this guidance as illustrating relevant good practice. However, dutyholders are not required to follow this guidance and compliance with it does not automatically mean that we will approve an application for a nuclear site licence, a consent or agreement under the licence or a permit/authorisation. The guidance provides information to other parties who may be stakeholders in how radioactive waste is managed on a nuclear licensed site.

Policies for the disposal of higher activity waste differ in Scotland and in England/Wales. We consider that packages conditioned in anticipation of geological disposal are also suitable for long-term storage, as required by Government policy in Scotland. On this basis the following guidance can be used equally in England, Scotland and Wales, but any references to geological disposal will mean long-term storage when applied to Scotland. We will keep the packaging advice being developed by the Nuclear Decommissioning Authority's (NDA's) Radioactive Waste Management Directorate (RWMD) under review and, if any developments mean that this assertion for Scottish waste is no longer valid, we will provide further guidance.

Given the long timescales involved in radioactive waste management, you should be aware that standards, legislation and national policy might change. While this guidance forms the best advice that the regulators can give at present, nothing in this guidance overrides, or is intended to pre-empt, the ability of the regulators to discharge their statutory powers and duties in accordance with legislation, standards and policy applicable at any time.

We will review this guidance periodically to ensure that it continues to provide sound advice.

Freedom of information – disclosure of information

The regulators are public authorities for the purposes of the Freedom of Information Act 2000 (FOIA00) and the Environmental Information Regulations 2004 (EIR04) in England and Wales, and the Freedom of Information (Scotland) Act 2002 (FOISA02) and the Environmental Information (Scotland) Regulations 2004 (EISR04) in Scotland. If we receive a request for information that we hold, we will have to consider the request in accordance with this legislation.

This document is available on our websites, in accordance with our policies of openness and transparency.

Executive summary

This document provides an overview of the relevant policy drivers, regulatory requirements and expectations relating to waste conditioning and disposability during the management of higher activity radioactive wastes on nuclear licensed sites. It also identifies the technical considerations that need to be addressed in the requisite radioactive waste management cases.

Scope

1 This document is part of a suite of guidance documents covering the management of higher activity radioactive waste on nuclear licensed sites.

2 In the context of this guidance:

- management of radioactive waste means the whole process of managing waste from its generation to (but not including) its disposal;
- higher activity radioactive waste means HLW, ILW , and such LLW as cannot be disposed of at present. If there is doubt over how to regard a particular waste stream, the owner of that waste stream should consult the regulators.

3 Advice about the disposal of those categories of radioactive waste that are not covered in this guidance can be obtained from the Environment Agency or SEPA.

4 Policies for the disposal of higher activity waste differ in Scotland and in England/Wales. We consider that packages conditioned in anticipation of geological disposal are also suitable for long-term storage, as required by Government policy in Scotland. On this basis the following guidance can be used equally in England, Scotland and Wales, but any references to geological disposal will mean long-term storage when applied to Scotland. We will keep the packaging advice being developed by the NDA's Radioactive Waste Management Directorate (RWMD) under review and, if any developments mean that this assertion for Scottish waste is no longer valid, we will provide further guidance.

5 Licensees are reminded that the same safety and environmental standards apply to all activities involving radioactive materials whether or not the material involved is declared as radioactive waste.

Objective

6 The objective of this document is to provide guidance on complying with the legislation below in accordance with current policy by:

- describing regulatory expectations in relation to the conditioning of higher activity wastes;
- outlining regulatory expectations with respect to waste disposability and the assessment thereof; and,
- providing links to other guidance on how these components of the radioactive waste management case (RWMC)[1] may be produced.

Applicable legislation and Government policy

7 Key legislation with respect to radioactive waste is as follows:

- Nuclear Installations Act 1965 (as amended);[2]
- standard conditions applied to nuclear site licences;[3]
- Health and Safety at Work etc Act 1974;[4]
- Radioactive Substances Act 1993 (RSA93);[5]
- Environmental Permitting Regulations (England and Wales) 2010;[6]
- conditions attached to permits under EPR 2010 or authorisations under RSA 93.

8 In England and Wales, radioactive substances regulation was incorporated into the Environmental Permitting Regulations (EPR) on 6 April 2010. EPR 2010 is regulated in England and Wales by the Environment Agency. In Scotland RSA 93 is regulated by the Scottish Environment Protection Agency (SEPA) and in Northern Ireland by the Northern Ireland Environment Agency.

9 For England and Wales, Environment Agency guidance[7] on the regulation of radioactive substances on nuclear licensed sites has been updated for EPR 2010.

10 Government maintains and continues to develop a policy and regulatory framework which ensures that:

- radioactive wastes are not unnecessarily created;
- such wastes as are created are safely and appropriately managed and treated; and
- they are then safely disposed of at appropriate times and in appropriate ways.

11 The fundamental aim is to ensure that radioactive waste is managed in a way that protects the health and interests of people and the integrity of the environment, both now and in the future, inspires public confidence and takes account of costs.

12 Command 2919[8] published in 1995, outlined the policy on the conditioning of wastes in the context of foreclosure of options, '*The Government believes that where the demands of safety are overriding, waste must be treated as necessary to improve storage conditions. In addition, where early treatment of waste will secure worthwhile safety benefits, or worthwhile economic benefits without prejudicing safety, the general presumption against action which might foreclose future waste management options may be relaxed. The relevant costs and commercial risks must be borne by the owner of the waste.*' A Government policy statement on the decommissioning of the UK nuclear industry's facilities was published in 2004[9] This confirmed that waste conditioning in accordance with Nirex's Letter of Comfort process[*] (now termed 'Letter of Compliance'[10]) should be pursued, '*Unless alternative arrangements come into effect in future, the Government confirms that operators should continue to process their decommissioning wastes, where appropriate, in accordance with Letter of Comfort arrangements*.' Publication of the Government White Paper "Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal"[11] in June 2008 confirmed geological disposal as Government policy and the desired way forward in England and Wales and stated (Paragraph 4.7), '*emphasis is on early immobilisation of operational and legacy waste materials to reduce their hazard. Such packaged wastes need to be placed into appropriate interim storage until they can be disposed of in the geological*

[*] Responsibility for operation of the Letter of Comfort (LoC) process (now termed 'Letter of Compliance') has transferred to the NDA (RWMD), which has assumed many of Nirex's former responsibilities. These responsibilities include operation of the LoC process planning and implementing geological disposal and operation of the LoC process.

disposal facility (GDF). Package requirements are kept under review by the NDA's Radioactive Waste Management Directorate (RWMD), under arrangements scrutinised by the regulators so as to minimise the possibility that wastes in interim storage will have to be repackaged prior to disposal in the GDF. Following consultation on a proposed detailed statement of policy during 2010, the Scottish Government published "Scotland's Higher Activity Radioactive Waste Policy"[12] in January 2011. Scottish Government policy is that the long-term management of higher activity radioactive waste should be in near-surface facilities located as near to the site where the waste is produced as possible.

13 The past policy (up to 1995) of not foreclosing options has meant that only a small proportion of ILW has been conditioned to date and large quantities of ILW have instead been stored in a raw (unconditioned) form. More recently, the Nuclear Installations Inspectorate (NII) has increased its emphasis on the need for potentially mobile wastes to be conditioned to an inherently safer, more passive form. Particular concern is on historical wastes, which in some cases are poorly characterised, physically and chemically and/or biologically degraded, and held in old facilities at risk of deterioration.

14 The Government requires that the regulators ensure that the policy and regulatory framework is properly implemented in accordance with statutory powers. Within the framework, the producers and owners of radioactive waste are responsible for developing their own waste management strategies, consulting the Government, regulatory bodies and disposal organisations as appropriate.

Other relevant guidance

15 HSE's Safety Assessment Principles[13] (SAPs) apply throughout the UK. Seven principles are defined under the broad heading of, 'Radioactive Waste Management' and each is generally applicable to waste conditioning. Key principles of relevance to this guidance document are:

- SAP RW.1 states: 'A strategy should be produced and implemented for the management of radioactive waste on a site.'
- SAP RW.4 states: 'Radioactive waste should be characterised and segregated to facilitate subsequent safe and effective management.'
- SAP RW.5 states: 'Radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition.'
- SAP RW.6 states: 'Radioactive waste should be processed into a passively safe state as soon as is reasonably practicable.'
- SAP RW.7 states: 'Information that might be required now and in the future for the safe management of radioactive waste should be recorded and preserved.'

16 For England and Wales, The Environment Agency's *Radioactive Substances Regulation: Environmental Principles*[14] apply. Fifteen principles are defined under the broad heading of, 'Radioactive Substance Management (including Waste Disposal)' and each is generally applicable to conditioning and disposability. The principles that are most relevant to this guidance document are:

- Principle RSMDP4: Methodology for Identifying BAT. The best available techniques should be identified by a methodology that is timely, transparent, inclusive, based on good quality data, and properly documented.
- Principle RSMDP5: Actions having Irreversible Consequences. Actions with radioactive substances having irreversible consequences should only be undertaken after thorough, detailed consideration of the potential consequences of those actions and of the other available options. The best available techniques should be used to prevent irreversible consequences from occurring inadvertently.
- Principle RSMDP7: BAT to Minimise Environmental Risk and Impact. When making decisions about the management of radioactive substances, the best available techniques should be used to ensure that the resulting environmental risk and impact are minimised.
- Principle RSMDP9: Characterisation. Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal.
- Principle RSMDP10: Storage. Radioactive substances should be stored using the best available techniques so that their environmental risk and environmental impact are minimised and that subsequent management, including disposal, is facilitated.
- Principle RSMDP11: Storage in a Passively Safe State. Where radioactive substances are currently not stored in a passively safe state and there are worthwhile environmental or safety benefits in doing so then the substances should be processed into this state.
- Principle RSMDP14: Record Keeping. Sufficient records relating to radioactive substances and associated facilities should be made and managed so as: to facilitate the subsequent management of those substances and facilities; to demonstrate whether compliance with requirements and standards has been achieved; and to provide continuing assurance about the environmental impact and risks of the operations undertaken, including waste disposal.
- Principle RSMDP15: Requirements and Conditions for Disposal of Wastes. Requirements and conditions that properly protect people and the environment should be set out and imposed for disposal of radioactive waste. Disposal of radioactive waste should comply with imposed requirements and conditions.

Guidance on waste conditioning

Waste conditioning

Wastes should be conditioned to yield products that are passively safe, transportable and ultimately disposable

17 Waste conditioning involves transforming radioactive waste into a form suitable for handling, transportation, storage and disposal.[*] Conditioning may include some or all of the following stages: the conversion of the waste to a solid wasteform, enclosure of the waste in containers and, if necessary, provision of an overpack. For brevity 'conditioning' is used in this document to include all stages of the process, except where it is necessary to refer to one of the stages specifically.

18 Conditioning may be accomplished in a single stage (e.g. within one facility) or may be achieved through multiple stages. Ideally there should be a single stage conditioning process, so as to avoid multiple handling operations, limit the requirement for significant future interventions and minimise future burdens.

19 At all stages of waste management the aim should be to ensure that radioactive waste is managed in a way that protects the health and interests of people and the integrity of the environment, both now and in the future, inspires public confidence and takes account of costs. Where a multi-stage conditioning route is chosen risks and environmental impacts during and between all stages should be reduced so far as is reasonably practicable and should be appropriately balanced. Each stage should generally give an overall improvement (e.g. improved containment and/or passive safety of the waste). Any conditioning process should take account of and not compromise the envisaged downstream management/disposal arrangements (e.g. acceptance criteria for stores).

20 Waste conditioning should yield waste packages that are:

- passively safe and suitably robust physically, so as to ensure containment and safe handling during any future periods of storage. The aim should be to minimise the need for active safety systems, monitoring or human intervention whilst the waste remains under institutional control;
- suitable for safe transport through publicly accessible transport routes in compliance with the relevant waste transport regulations.[†] In this regard the waste packages may themselves be approved transport containers or may be of a design which facilitates transport in approved, preferably reusable, transport containers/flasks;
- disposable, such that the nature and properties of the conditioned waste product are compatible with the anticipated standards for eventual disposal e.g. Waste Acceptance Criteria (WAC) of an appropriate disposal facility.

21 A wide range of technical, engineering and management considerations are relevant to waste conditioning programmes, to ensure that the conditioned waste products are fit for purpose. Relevant considerations include, but are not limited to, the following:

- the nature of the waste and its characterisation (related aspects are covered in Part 3a of the Joint Guidance[15]);
- when to condition the waste;
- whether the activity associated with the waste needs to be immobilised within the waste container and, if so, the method of waste immobilisation;

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[*] Any specific references to geological disposal will mean long-term storage when applied in Scotland.
[†] The Department for Transport is competent authority in the UK and should be consulted for further advice.

- the design, manufacture and quality assurance of the waste containers to be used;
- the conditioning process, including the relevant plant specifications, design and operation, to ensure the production of 'fit for purpose' conditioned waste products;
- interim storage and monitoring arrangements for the conditioned wastes (related aspects are covered in Part 3c of the Joint Guidance[16]);
- quality assurance arrangements over all stages of waste management until disposal;
- waste package records and their long-term retention (related aspects are covered in Part 3d of the Joint Guidance[17]).

Waste packages should maintain their safety functions throughout the anticipated storage period including, as appropriate, after emplacement in a disposal facility

22 Conditioned waste packages perform a number of important safety functions including:

- Containment, of the radioactive inventory during normal operations and accident conditions;
- Shielding, during transport and storage (particularly important for packages that will be transported without overpacks and/or stored in unshielded stores);
- Handling, by incorporation of lifting features;
- Stacking, during interim storage and emplacement in a disposal facility;
- Identification, by unique markings;
- Non-pressurisation, by control of physical and chemical inventory and/or by incorporation of filters, seals or vents;
- Maintaining sub-criticality.

23 Waste packages should maintain their safety functions throughout the anticipated storage period, including, as appropriate, after emplacement in a disposal facility. During storage on nuclear licensed sites, waste producers will be expected to monitor waste packages to demonstrate that these safety functions are not being threatened or compromised (see the guidance module on Storage).

When to condition waste

Waste should be conditioned to a safe, passive, transportable and disposable form as soon as is reasonably practicable

24 Our expectation, consistent with Government policy, is that wastes will be conditioned to a safe and passive form as soon as is reasonably practicable. The aim should be to avoid raw waste accumulation, such that new wastes should be conditioned as they arise, where practicable. The regulators expect that full and timely use will be made of any routes for the disposal of radioactive waste once they become available.

25 We recognise that there may be specific drivers for conditioning where, for example:

- wastes are held in deteriorating facilities and retrieval is necessary;
- existing waste storage arrangements need to be improved;
- provisions can be made to condition the waste as it arises and the accumulation of raw wastes can be prevented;
- conditioning plant is available that has the capacity and functionality to condition the waste, thus providing an opportunity for appropriate, timely and cost-effective waste conditioning;

- a disposal route already exists and waste requires conditioning to facilitate safe transport to the disposal site and to meet the Waste Acceptance Criteria (WAC) at the disposal facility.

Waste conditioning approaches

An operator should appraise the available options to ensure that the conditioning approach chosen is demonstrably optimised for radiological protection of workers and the public

26 Council Directive 96/29/EURATOM, Article 6.3(a)[18] requires that the management of radioactive waste is optimised, so that all resulting exposures to ionising radiation of any members of the public and of the population are kept as low as reasonably achievable (ALARA), economic and social factors being taken into account. This requirement is enacted in England, Wales and Scotland by a number of statutory instruments[19,20, 21]

27 The environment agencies' have published guidance on the principles of optimisation in the management and disposal of radioactive waste[22]. The optimisation requirement applies not only to the conditioning process itself, but throughout the lifetime of the conditioned waste package. To decide which conditioning process to use, the operator should identify the available options and choose the one which best meets the optimisation requirement.

28 We expect the operator to use an options assessment process which follows the environment agencies' "Guidance for the Environment Agencies' Assessment of Best Practicable Environmental Option Studies at Nuclear Sites"[23]. The process should be robustly supported by well informed and substantiated decision-making, be open to scrutiny by regulators and by other stakeholders, and take account of, amongst other things:

- possible imbalances or biases in the information supporting competing options;
- optimisation constraints such as secondary waste generation, practicality, reliability, cost and wider social and economic factors;
- known uncertainties with the performance of the conditioning process and the withstand capability of conditioned waste packages to uncertainties in anticipated storage environment and future handling and transport requirements up to the time of disposal;
- information from the operator or prospective operator of the relevant disposal facility about the disposability of the waste conditioned in accordance with each available option; and about the length of time relevant parts of the facility might remain open after emplacement.

29 We expect the operator to employ sound judgement when using the options assessment as an aid to deciding which conditioning process best meets the optimisation requirement for the radiological protection of workers and the public, both during and after conditioning.

30 The overall conditioning process should be technically underpinned and this may require programmes of experimental and developmental work and/or reliance on established knowledge and operational experience. Development work may need to include both inactive and active development trials, which may include both small-scale (laboratory) and full-scale trials (e.g. on development rigs or plant prior to active commissioning). The combined development programme will need to demonstrate that the conditioning process will produce fit-for-purpose, quality-assured waste products and that the process can accommodate any potential variations in waste feeds.

Preparing wastes for conditioning

The need for, and benefits of, waste pre-treatment processes prior to conditioning, should

be evaluated

31 For some wastes e.g. those with a high degree of homogeneity already, it may be appropriate to condition the raw waste directly with minimum pre-treatment or sorting and segregation. However, this will not be appropriate for all wastes.

32 Sorting and segregation of wastes should be adopted, where practicable, if this provides:

- a net benefit in terms of radiological risks overall; or
- significantly reduces HAW disposal volumes; or
- significantly reduces risks and/or uncertainties for future waste management.

33 This is discussed further in Part 3a of the Joint Guidance.

34 The need for, and benefits of, waste pre-treatment processes prior to conditioning, such as drying, dissolution, incineration, pyrolysis or super compaction, should be evaluated by the operator as a part of the overall options appraisal process. Waste pre-treatments should be implemented if they are needed, or are practicable and can be shown to provide a net benefit. In particular, pre-treatment should be considered for the purpose of:

- removing or suppressing chemical reactivity or biological degradation within the waste that could present a challenge to its long-term management and eventual disposal;
- drying wastes, if containerisation without immobilisation is pursued, to minimise the risk of corrosion and gas generation;
- enabling significant reduction in conditioned waste volumes.

Waste immobilisation

The immobilised wasteform provides an important contribution to the waste package performance

35 Immobilisation of readily mobilised or dispersible waste is usually achieved by conversion of the raw waste into a solid wasteform (e.g. by encapsulation or vitrification) as a part of the waste conditioning process. Immobilisation will generally be required for wastes that contain free liquids, slurries, sludges or readily dispersible particulate material. In particular, free liquids should be eliminated and ideally readily dispersible material should be fixed, eliminated or minimised. The resultant wasteform then contributes to overall waste package performance (the ‘containment’ safety function).

36 The immobilisation process should be selected by the operator as part of the overall options appraisal, on the basis of the properties of the waste to be treated and the hazard that it presents. Examples include dewatering, encapsulation in a suitable matrix (e.g. composite cement, a thermosetting polymer), vitrification or conversion to a ceramic form. Following immobilisation, the resulting wasteform should be shown to restrict the movement of radioactive and hazardous waste constituents as expected.

37 Where wastes are not to be immobilised to yield a solid wasteform, the operator should demonstrate that the waste container will provide sufficient containment at all times so as to ensure safety during all operations, transport, storage and disposal, during both normal and accident scenarios. Consideration should also be given to the possibility of any constituents of the waste becoming mobile during storage (e.g. through reactions to yield powders, gases or to generate liquid phases from the degradation of organic matter). Appropriate measures should be taken to avoid or minimise the possibility of such effects.

38 An immobilised wasteform provides an important contribution to the waste package performance and package safety functions. For example, immobilisation may yield wasteforms that in themselves provide a containment barrier and also provide structural support. The performance of the wasteform and the container need to both be considered as constituents of the waste package.

Wasteforms

39 The wasteform* properties are a significant factor in determining package safety particularly with respect to the potential for migration and/or dispersion of waste constituents. Its performance should be evaluated for handling, transportation, storage and disposal under both normal and accident conditions.

40 Wasteforms should typically:

- contribute, as far as is practicable, to the retention of radionuclides and hazardous waste constituents under both normal and accident conditions during handling, transportation, storage and disposal. The risks to the public or workers from potential accident scenarios should be ALARP;
- contribute to meeting the requirements of the waste transport regulations;
- exhibit and retain sufficient mechanical strength as required for safe handling, stacking and transportation;
- contain minimal voidage, as far as is practicable;
- contain minimal free liquids, as far as is practicable;
- be stable against physical, chemical and biological degradation, such that they evolve only slowly under normal conditions, as anticipated during storage, transport and disposal. Any deleterious reactions, which may pose a threat to package performance, should exhibit very low rates such that any resulting impacts are avoided, or can be safely managed;
- not undergo extensive dimensional changes or cracking and should not allow the formation of significant quantities of gas, liquid or expansive solid secondary products if these might compromise safety or result in significant environmental impacts;
- be suitably resistant to the expected thermal and radiation environments such that any degradation will not compromise the safety case.

41 Wasteforms will also contribute to overall performance of the eventual disposal facility and should ideally:

- exhibit good resistance to leaching and low solubility in groundwater;
- be homogeneous, so as to minimise any local effects within the wasteform and provide a better basis for assessment of likely performance over time;
- evolve in a controlled manner, such that their long-term behaviour can be more readily assessed.

42 Waste container integrity could be threatened by corrosive constituents of the wasteform or by by-products of reactions occurring within the wasteform. Wastes and wasteforms should not contain or give rise to materials that might significantly threaten the integrity of the waste container.

Waste containers

Waste containers should incorporate suitable design features to ensure the safety functions required are maintained for package handling through the successive phases of

* In the case of wastes that are not immobilised (e.g. containerised raw wastes that are intended for direct disposal) the waste itself constitutes the wasteform.

waste management

43 The waste container should provide appropriate containment of the waste through all phases of waste management, consistent with the relevant safety cases required. The container materials should be chosen to provide the necessary performance for the envisaged storage and disposal environments, for the required periods.

44 Waste containers should incorporate suitable design features to ensure the safety functions required are maintained for package handling through the successive phases of waste management, including off-site transport and eventual disposal. There may be significant advantages in adopting standardised, fit-for-purpose container designs.

45 Where gas generation is anticipated, containers should be designed appropriately e.g. to include features to avoid over-pressurisation (e.g. gas vents) but to retain particulates (e.g. filters in the gas venting system).

46 The waste container, including any integral handling or lifting features, should be suitably resistant to processes that could adversely alter material properties and cause early failure. For metallic containers this should include resistance to general and local corrosion mechanisms (e.g. pitting or crevice corrosion) and stress corrosion cracking under the envisaged storage conditions.

47 Corrosion resistance might be achieved through an appropriate combination or choice of materials, suitable storage conditions, protective coatings or other methods, such as anodic protection. The corrosion resistance of waste container materials should be known or investigated experimentally, taking into account the time periods and environments relevant to the anticipated storage, transport and disposal of the waste packages.

48 Atmospheric corrosion should be minimised by ensuring favourable environmental storage conditions (with active control as required) and by appropriate store management and inspection arrangements (see the guidance module on Storage).

49 Containers should be manufactured to defined specifications within an appropriate quality assurance regime. Arrangements should be established to ensure that any defective or damaged containers are identified prior to use and rejected or repaired. Handling and storage of containers prior to use should be managed to minimise the possibility of surface contamination (e.g. by corrosive agents).

50 The location and the exact contents of each waste package should be known at all times. To facilitate this, each container should be marked with a unique identifier linked to its appropriate package and location records. Package identifiers will need to remain legible for the long period until the end of institutional control of that waste (e.g. for packages destined for geological disposal this could be several hundred years after closure of a geological facility).

Waste package performance and longevity

The design life of waste packages should be consistent with the national strategies for waste management

51 During the functional lifetime of a package its safety functions should be such that they meet the requirements of the relevant safety cases at that time, including the case for transport where appropriate and other anticipated package movements.

52 The design life of waste packages should be consistent with the national strategies for waste management and, in England and Wales, disposal. Package design life should encompass the timescales associated with the future phases of waste management, including storage, transport and disposal, as anticipated at the time of manufacture.

53 Waste package designs, waste conditioning practices and management arrangements for conditioned waste during storage should be appropriate to ensure package longevity, so far as is reasonable practicable (further discussed in the guidance module on Storage).

54 Good engineering practice should be adopted for container and package construction. A minimum package lifetime of 150 years should be set for design purposes. Caution is needed in projecting package lifetimes to several centuries or more given the current state of knowledge and the uncertainties relating to waste package ageing and the ability to maintain appropriate storage conditions over extended timescales (see the guidance module on Storage).

55 A programme of package monitoring and inspection should be implemented (see the guidance module on Storage).

56 Identification of any potential package degradation mechanisms that may threaten package safety functions will be expected as a part of the RWMC. Such information should be used to inform package monitoring and inspection strategies and to underpin early thinking as to what package rework or remediation measures may be required.

57 As indicated earlier, waste package longevity should be a specific consideration during options appraisal. Appropriate strategies to produce robust packages and to promote package longevity should be considered and adopted, where practicable.

58 Particular approaches to ensure longevity could include, but are not limited to, the following:

- sorting and segregation of mixed wastes that may be mutually incompatible(see the guidance module on Waste minimisation, characterisation and segregation);
- removing or reducing waste reactivity by treatment prior to or during waste conditioning;
- using waste conditioning matrices that are inert or beneficial with respect to the container material and the waste; and
- periodic package inspection followed by appropriate remedial action, where necessary. For example, this could include remediation of any early package faults to mitigate further degradation or checking of waste containers for signs of corrosion followed by appropriate remedial actions where problems are identified.

59 Package remediation or reworking should be considered at any time between package manufacture and disposal in cases where:

- packages fail to meet the appropriate safety case requirements for the current phase of waste management;
- it becomes apparent that package safety functions are being threatened (e.g. by corrosion);
- it becomes apparent that the packages are not compatible with the requirements of a subsequent phase of waste management or disposal.

Radionuclide Inventory

The radionuclide content of each waste package should be known in sufficient detail, and with sufficient accuracy, to meet safety case and disposal requirements

60 The radionuclide and hazardous material inventory of each waste package or waste stream should be known with sufficient detail and accuracy to meet the appropriate safety cases and disposal requirements.

61 Knowledge of the radionuclide inventory of each waste package should extend through measurement and/or assessment to an understanding of:

- the radionuclide inventory of the package (noting this is needed for storage and handling purposes and to define the total inventory for a disposal facility);
- package dose rates;
- contamination levels on external container surfaces;
- the radiogenic heat output of the package.

62 The aim should be fully to characterise the waste prior to conditioning, taking account of the information needs through to disposal. Good record keeping is particularly important given information and records will be needed over extended timescales to support ongoing waste management and disposal (see the guidance module on managing information and records relating to radioactive waste) . Package records and monitoring history should be readily available for inspection.

Reactive, hazardous and challenging materials

Appropriate controls or limits should be placed on materials that might react adversely within waste packages, or which might pose a threat to passively safe storage, transport or disposal

63 The conditioning process and processing environment should ensure that any chemically reactive, biologically degradable, hazardous and challenging materials[*] present within the waste are identified and appropriately controlled. Controls might extend, for example, to placing limits on the quantities of such material per package or ensuring that any related hazards are suitably managed by the choice of encapsulating matrix and/or container design. Specific consideration should be given to:

- organic waste constituents: particularly those that present a hazard based on their inherent toxicity might degrade to yield gases that contain radioactive isotopes, might be explosive or present a flammability hazard, might influence the neutron reactivity of the system, might degrade to form species which challenge the waste container or might enhance/promote the mobility of radionuclides in the disposal environment;
- chemically reactive constituents: particularly those that might be expected to react adversely within the waste matrix, with the container or with each other. Examples include metals or ion exchange materials that react with the waste matrix to form reaction products of greater volume and could thus disrupt the waste package, graphite which may have associated Wigner energy, and materials which may significantly influence the pH of the wasteform or challenge the container integrity;
- explosive, flammable, combustible, corrosive and pyrophoric materials: including any waste constituents which might evolve to form materials with such properties in the long term; and
- any materials that would be classed as dangerous goods for transport purposes or material covered under the Hazardous Waste (England and Wales) Regulations[24] and the Special Waste Regulations[25] (in Scotland).

Fissile material

Waste package fissile limits should be derived via appropriate assessments covering the handling, storage, transport and disposal phases of waste management.

[*] In this context reactive, hazardous and challenging materials are those that are significantly toxic or hazardous to health, gas generating and/or corrosive.

64 Criticality safety principles apply to the processing, handling, storage, conditioning, transport and disposal* of waste containing fissile material. Criticality safety should be achieved by system design in preference to reliance on administrative safety measures as far as is reasonably practicable.

65 No external controls should be relied upon to prevent criticality. Facility safety cases will need to demonstrate acceptable sub-criticality margins during storage, taking account of possible accident conditions, e.g. flooding, and any uncertainties that may exist. Engineered controls may include safe geometry, structural separation and the use of neutron absorber materials (i.e. neutron reactivity poisons), where appropriate. Safety cases for multiple fissile units in storage arrays should take account of neutronic interactions between the units.

66 Waste package fissile limits should be defined such that criticality events are not credible, wherever fissile materials may be present. Waste package fissile limits should be derived via assessments to cover the handling, storage, transport and disposal phases of waste management.

67 It may be appropriate to characterise waste streams according to their intrinsic neutron absorption and moderation properties. Reduction in the uncertainty in the quantities of neutron absorbers and moderators present in the waste may in turn lead to an increase in permissible levels of fissile material per waste package.

68 Package design and loadings should be such that a criticality event is not credible against identified faults during operations and transport. At the time of waste package transport the fissile content of the waste, its packaging and condition must be such as to satisfy the requirements of the waste transport regulations.

69 Waste conditioning operations should be suitably controlled so as to ensure compliance with the relevant waste package fissile limit. Where the fissile content of the waste is determined during the conditioning operation the sampling error and assay system error should be considered in calculations to determine operational compliance with fissile mass limits. Following conditioning the fissile content of the waste package should be known with sufficient accuracy to ensure compliance with the relevant fissile limits and any other requirements, such as safeguards.

Waste package specifications

70 RWMD's disposal concept is underpinned by a suite of documents including RWMD's waste packaging specifications and associated guidance. Waste package specifications are owned by RWMD. For higher activity wastes, destined for disposal in a geological facility, licensees make proposals for the packaging of the wastes, and RWMD conducts disposability assessments of them by comparison with published waste package specifications and their disposal concept. RWMD assess licensees' packaging proposals through the Letter of Compliance process and, if appropriate, issue Disposability Assessment reports containing Action Points detailing where additional information or safety arguments are required. Where compliance can be demonstrated, this is recognised by RWMD through issue of Letters of Compliance.

Waste product specifications

71 Waste product specifications are owned by the licensee and endorsed by RWMD through the LoC process. Waste product specifications are written to ensure that the packaging process is quality assured and documented such that the packages produced are compliant with RWMD's LoC endorsement.

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* Guidance on treatment of criticality in a geological disposal facility is provided separately[26]

72 Waste product specifications will be used, together with lifetime package records, to demonstrate that waste packages meet the facility safety cases and the (anticipated) WAC for future stages of waste management and disposal.

73 Waste product specification should be kept up to date and revised as appropriate to reflect the 'as made' packages (e.g. if waste feeds or processing parameters are subsequently changed from those originally endorsed by RWMD). Where any changes may affect disposability, they should be shared with RWMD in addition to any local product quality review committee.

74 The relevant RWMC, or documents supporting it, should describe the control measures for detecting any out-of-specification or non-conforming packages produced and the arrangements for the management of any such packages and the measures to bring them back into conformance.

Information and records relating to conditioned waste

It is the responsibility of the licensee to provide the necessary assurances on the quality of the waste product

75 Information management requirements are discussed in the guidance module on managing information and records relating to radioactive waste.

76 Quality management should be applied to all aspects of the conditioning of radioactive wastes that affect the quality of the waste package product. The Quality Management System (QMS) should comply with a suitable quality standard (e.g. ISO 9001).

77 It is the responsibility of the licensee to provide the necessary assurances of the quality of the waste product.

78 Information and records should be assembled for and about each waste package (referenced by unique package identifier) containing all relevant details of the package including manufacture and contents. Such information will normally include, but is not limited to:

- the wastes, including description and origin;
- the wasteforms, including formulation and chemical constituents;
- the containers in which the waste is placed;
- the conditioning and packaging processes;
- process conditions;
- storage conditions;
- all relevant supporting R&D (including product properties and performance);
- waste package radionuclide and physical/chemical inventory;
- conditioned waste package properties, including reference to the relevant waste product specification;
- waste package history, including the storage conditions it has encountered;
- specific safety and other criteria such as those imposed, for example, by criticality compliance, international safeguards and hazardous waste regulations; and
- administrative information, including records of authorisation for final disposal.

79 Package information and records must be suitable for use by the licensee and others e.g. RWMD, third party auditors and regulators. For example, they may be required to support ongoing endorsement

through the LoC process (where appropriate), to demonstrate compliance with transport requirements or to meet acceptance criteria at storage and disposal facilities.

80 Arrangements for assuring the quality of processed waste should be addressed in the licensee's quality management system. This will include the identification and monitoring of a range of properties sufficient to demonstrate that the waste product corresponds to the Waste Product Specification endorsed through the LoC process. Audits should be undertaken at appropriate intervals to provide confirmation that the overall packaging process, resultant products and records are compliant.

81 At set intervals, the licensee may be required to check properties relating to the integrity of conditioned packages in stores. These investigations may provide a mechanism to allow early detection and correction of undesirable systemic changes in waste product quality.

82 The waste package quality checking programme should use the best available techniques to assess package status (see the guidance module on Storage). In appropriate cases, consideration should be given to the use of radiographic and other non-destructive techniques. Appropriate statistical procedures should be employed in relation to sampling of packages for inspection.

Guidance on disposability

Disposability

It is the responsibility of the licensee to produce and understand the RWMC

83 Disposability refers to the degree to which conditioned waste meets the standards and specifications for final disposal. To ensure disposability, waste packages should be designed to ensure safe handling, storage and transport to the disposal site. At the point of consignment, waste packages will need to meet the WAC for that disposal facility which may include specific UK safeguards and security requirements. After disposal, the waste packages will provide barriers within the disposal system and hence their performance characteristics will have a direct effect on the post-closure performance of the disposal system. The safety case for the disposal system will need to include consideration of the combined performance of all the barriers for an extended timescale, beyond the period of institutional control. Separate guidance discusses regulatory expectations in relation to waste disposal[23]. Although the separate guidance is aimed predominantly at the designers and implementers of disposal facilities, rather than waste producers who are conditioning waste destined for disposal in such a facility, it is important that programmes to condition waste fully take into account the end requirements.

84 It is not possible to provide an absolute guarantee of disposability in the absence of a licensed and permitted/authorised disposal facility with fully developed and approved WAC. Accepting this limitation, RWMCs should demonstrate how wastes are being managed in this respect. Specifically RWMCs should include arguments and evidence to provide confidence that proposed or ongoing waste conditioning and storage operations will result in disposable waste products, to the extent that this can be demonstrated at any time. In many cases, the licensee's arguments will be supported largely by evidence obtained through interactions with RWMD via the LoC process. The level of detail that is provided by the licensee to demonstrate disposability should be appropriate in the relevant decision context. Disposability arguments are expected to become increasingly mature as waste conditioning programmes develop from the conceptual to the implementation phase. In particular, prior to waste conditioning there should be a high level of confidence that waste products will be disposable in the context of Government policy current at that time taking into account the status of any related national disposal programme.

Demonstrating disposability

85 It is the responsibility of the licensee to demonstrate disposability and to produce (and to maintain a continuing understanding of) the RWMC. However, information provided by the disposal facility operator, prospective operator (e.g. RWMD) or other third party (e.g. contractor) will form an important part of that demonstration. For example, for wastes which may be destined for deep geological disposal, a Letter of Compliance (LoC) can be issued by RWMD, stating that the conditioned waste is likely to be acceptable for future disposal The regulators expect the licensee to understand the basis of any such third party information or endorsement and to condition waste in accordance with any related endorsement conditions. Conditioning processes should be audited periodically to ensure the latter and to demonstrate appropriate waste product quality.

Ultimately, disposability will be demonstrated by meeting the WAC of the recipient disposal facility

86 The licensee's demonstration of disposability should be based on appropriate disposability assessments. In cases where waste is to be directed to an operating, licensed and permitted/authorised disposal facility with fully developed and approved WAC, this would involve establishing compliance with the facility WAC. The supporting arguments should be consistent with the scheduling of waste disposals at the proposed disposal site (e.g. whether the site will be accepting wastes at that time and if the site is likely to have sufficient remaining capacity).

87 Prior to the availability of an operating disposal facility, disposability assessments should be performed against suitable facility designs (or a reference concept or concepts), which are supported by safety cases, including environmental safety cases. It would not be acceptable, for example, to argue that a bespoke disposal facility could be designed and developed at a future date to accommodate a particular waste stream, without underpinning this with detailed arguments relating to the proposed disposal facility design and the related safety case arguments.

88 We recognise NDA RWMD as the appropriate body to advise licensees on the packaging and conditioning for geological disposal of higher activity radioactive wastes. Such advice is provided through RWMD's LoC process. Provision of a LoC by RWMD indicates its endorsement of proposed or existing waste packages for geological disposal (noting LoC endorsements may be subject to Periodic Review by RWMD). Endorsement through the LoC process should not be confused with and does not necessarily imply regulatory endorsement, nor should it be viewed, necessarily, as a prerequisite to obtaining regulatory consent for waste conditioning.

Specific disposability considerations for RWMCs

Disposability considerations should encompass any potential interactions of significance between the waste and its disposal environment

89 The following paragraphs provide further guidance on what we expect to see in RWMCs.

90 The RWMC should highlight any significant implications that the waste will have on the performance of the relevant disposal facility and any implications for handling and transport operations between the site of origin and the disposal facility.

91 Specific considerations should include, for example, assurance that:

- the composition of the conditioned waste, e.g. its radionuclide inventory and the presence of any reactive or toxic constituents, is known in sufficient detail to allow future compliance with the WAC to be determined (see the guidance module on Waste minimisation, characterisation and segregation);
- the conditioned waste package meets current requirements for transport to a future disposal site;
- the waste can be safely handled and managed within a disposal facility during emplacement and prior to facility closure (including any package retrieval operations where the design includes that provision);

92 Key issues should be assessed and assurances given that there will be no significant concerns in relation to the performance of the disposal facility. Such issues may include for example:

- radionuclide transport through the gas and groundwater pathways;
- package decay heat and potential effects on the proposed barrier components and safety functions of the disposal system;
- maintenance of sub-criticality;
- adverse reactions between the waste and the conditioning matrix, e.g. assessment of the potential for cracking and chemical degradation;
- detrimental effects due to chemical species that may be present in the wastes or might be expected to form as a result of chemical or biological degradation, e.g. species that might enhance radionuclide mobility following disposal through chemical complex formation;
- impacts from any toxic waste constituents.

93 If it is concluded that there are significant issues that may challenge disposability, these issues should be set out together with any assumptions made in arriving at that conclusion (e.g. incompatibility with a specific facility design concept or feature thereof, incompatibility of the transport container with standard designs, or issues that may restrict the future choice of a geological environment for the disposal facility). For each of the issues, the RWMC should discuss the likelihood and the potential impact of the issue and any proposed solutions (e.g. mitigation by modifications to the disposal facility design).

References

1 *The management of higher activity radioactive waste on nuclear licensed sites: Part 2 Radioactive waste management cases* NRW04 HSE, Environment Agency, SEPA 2010 www.hse.gov.uk/nuclear/wastemanage.htm

2 *Nuclear Installations Act 1965 (c57)* The Stationery Office 1965 ISBN 978 0 10 850216 3

3 *Nuclear site licence conditions* HSE www.hse.gov.uk/nuclear/silicon.pdf

4 *Health and Safety at Work etc Act 1974 (c37)* The Stationery Office 1974 ISBN 978 0 10 543774 1

5 *Radioactive Substances Act 1993 (c12)* The Stationery Office 1993 ISBN 978 0 10 541293 9.

6 *Environmental Permitting Regulations (England and Wales) 2010*. The Stationery Office SI 2010 No 675

7 *Regulatory Guidance Series, No RSR 2, The regulation of radioactive substances activities on nuclear licensed sites, Version 1*. Environment Agency, March 2010 http://www.environment-agency.gov.uk/static/documents/Business/GEHO0310BSGF-E-E.pdf

8 *Review of Radioactive Waste Management Policy – Final Conclusions. Command 2919,* HM Government 1995.

9 *The decommissioning of the UK nuclear industry's facilities* URN 04/1598 BERR September 2004.

10 *Guide to the Letter of Compliance Assessment Process* RWMD Document WPS/650 March 2008.

11 *Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal, Command 7386* A White Paper by Defra, BERR and the devolved administrations for Wales and Northern Ireland June 2008.

12 Scotland's Higher Activity Radioactive Waste Policy. The Scottish Government 2011 ISBN: 978 0 7559 9892 0. Available at: www.scotland.gov.uk/Publications/2011/01/20114928/0

13 *Safety Assessment Principles for Nuclear Plant* (2006 edition, Revision 1) HSE 2006. Available at: www.hse.gov.uk/nuclear/saps/index.htm

14 Regulatory Guidance Series, No RSR 1, *Radioactive Substances Regulation: Environmental Principles, Version 2,* Environment Agency April 2010. Available at: http://publications.environment-agency.gov.uk/pdf/GEHO0709BQSB-e-e.pdf

15 *The management of higher activity radioactive waste on nuclear licensed sites: Part 3a Waste minimisation, characterisation and segregation* NRW07 HSE, Environment Agency, SEPA 2010 www.hse.gov.uk/nuclear/wastemanage.htm

16 *The management of higher activity radioactive waste on nuclear licensed sites: Part 3c Storage of radioactive waste (draft for trial use and comment)* NRW09 ONR, Environment Agency, SEPA www.hse.gov.uk/nuclear/wastemanage.htm

17 *The management of higher activity radioactive waste on nuclear licensed sites: Part 3d Managing information and records relating to radioactive waste* HSE, Environment Agency, SEPA 2010 www.hse.gov.uk/nuclear/wastemanage.htm

18 *Council Directive 96/29/EURATOM of 13 May 1996 Laying Down Basic Safety Standards for the Protection of the Health of Workers and the General Public Against the Dangers Arising From Ionizing Radiation*. Official Journal L 159, 29.6.1996, p. 1 - 114.

19 *Radioactive Substances (Basic Safety Standards) (England and Wales) Direction 2000.* DETR 2000

20 *Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000.* Scottish Executive 2000.

21 *Ionising Radiations Regulations* Statutory Instrument 1999/3232

22 *Principles of optimisation in the management and disposal of radioactive waste,* Version 2, Environment Agency April 2010. www.environment-agency.gov.uk/static/documents/Business/GEHO0709BQSA-E-E.pdf ; and

Satisfying the ALARA requirement and the role of Best Practicable Means. SEPA 2010 www.sepa.org.uk/radioactive_substances/publications/idoc.ashx?docid=b9c441fd-defd-4364-bb06-874111d3f6bb&version=-1

23 *Guidance for the Environment Agencies' Assessment of Best Practicable Environmental Option Studies at Nuclear Sites* Environment Agency and Scottish Environment Protection Agency 2004. http://www.sepa.org.uk/radioactive_substances/publications/idoc.ashx?docid=2e360a4b-d0b8-4abe-9e1c-51eba529bbd0&version=-1

24 *The Hazardous Waste (England and Wales) Regulations* The Stationery Office 2005 ISBN 0110726855.

25 *Special Waste Regulations 1996* SI 1996/972 The Stationery Office 1996 ISBN 0 978 0 11 054565 3 as amended by *Special Waste (Amendment) Regulations 1996* SI 1996/2019 ISBN 978 0 11 062894 3.

26 *Guidance on Requirements for Authorisation* (for near surface disposal facilities and geological disposal facilities). Available at:
http://www.environment-agency.gov.uk/business/sectors/99322.aspx

Further reading

The management of higher-activity radioactive waste on nuclear licensed sites: Part I The regulatory process NRW01 HSE, Environment Agency, SEPA 2010 www.hse.gov.uk/nuclear/wastemanage.htm

Multi-criteria analysis: a manual. Available at
http://www.communities.gov.uk/publications/corporate/multicriteriaanalysismanual

What is a Hazardous Waste? A guide to the Hazardous Waste Regulations and the List of Waste Regulations in England and Wales. Environment Agency 2008
http://www.environment-agency.gov.uk/static/documents/GEHO0506BKTR-e-e.pdf

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Contacts

Office for Nuclear Regulation
Redgrave Court, Merton Road
Bootle, Merseyside L20 7HS
www.hse.gov.uk/nuclear

Environment Agency
Nuclear Waste Assessment Team
Environment Agency
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith, Cumbria CA11 9BP
www.environment-agency.gov.uk

Scottish Environment Protection Agency
SEPA Corporate Office
Erskine Court
Castle Business Park
Stirling FK9 4TR
www.sepa.co.uk

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