NUCLEAR SAFETY DIRECTORATE

GUIDANCE FOR INSPECTORS ON THE

MANAGEMENT OF RADIOACTIVE MATERIALS AND RADIOACTIVE WASTE ON NUCLEAR LICENSED SITES

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Contents

1. Purpose and Scope

1.1 This internal guidance describes the approach of HM Nuclear Installations Inspectorate (NII), which is part of the Health and Safety Executive's (HSE) Nuclear Safety Directorate (NSD), in respect of its responsibilities for the regulation of the management of radioactive material and radioactive waste on nuclear licensed sites. Consideration is given to both short and long term safety issues. The objectives of the guidance are:

- to draw together those aspects of legislation, Government Policy and international standards which are relevant to the work of NII in regulating the management of radioactive material and radioactive waste; and
- to provide a framework for the inspection and assessment of licensees' arrangements for the management of radioactive material and radioactive waste on a consistent basis, including the mechanisms of working with other regulators and Government Departments.

1.2 This guidance relates to the management of nuclear matter[1], including fissile material and all other radioactive material, which is currently being, or may in the future be, accumulated and stored on nuclear licensed sites. It covers the management of radioactive material and radioactive waste throughout their life-cycle of creation, accumulation, storage and, finally, disposal or some other long term solution. Radioactive material includes materials in-store prior to operational use (for example, new reactor fuel and radioisotopes) and also certain fissile and other radioactive materials which, although not currently regarded as waste, may become waste in the future or will continue to be stored. In all cases, these materials will require long term safe management in exactly the same way, and using the same principles, as are applied to the management of radioactive waste. Such radioactive material and waste may be generated as a result of activities associated with the nuclear fuel cycle, nuclear medicine, the military, research and many other industrial practices or as a result of decommissioning.

1.3 The guidance is intended to be applicable to the management of radioactive material and radioactive waste at all nuclear facilities on nuclear licensed sites, including nuclear power plant, nuclear chemical plant, storage facilities and disposal facilities. The management of radioactive material and radioactive waste, and the management of the decommissioning of nuclear facilities, are closely linked and these activities require an integrated approach.

1.4 The target audience within NII for this guidance is primarily assessment inspectors and site inspectors for nuclear sites where there are significant radioactive waste management and decommissioning activities. This guidance is incorporated on the Business Management System (BMS) as a

[1] The relevant legislation and literature refer variously to nuclear matter, radioactive material, radioactive waste and radioactive substances. For simplification, the terms radioactive material and radioactive waste will be used in this document as most appropriate in each context.

Technical Assessment Guide and inspectors will be directed to it as a main reference from the corresponding Inspection Guides. The guidance aims to set down a consistent framework for the assessment of licensees' proposals, but it is not intended to be prescriptive and inspectors should be flexible and prepared to consider alternative approaches that are put forward by licensees. As for all guidance, inspectors should use their judgement and discretion in the depth and scope to which they apply it.

1.5 Although the guidance has been produced for NII's internal use, it can be made available to external organisations and individuals who wish to inform themselves of NII's regulatory approach. Inspectors wishing to transmit the guidance outside NII should contact Unit 4c.

1.6 NII continuously reviews its regulatory approach and responds to developments, both national and international. This guidance will be updated to reflect such changing circumstances.

2. Legislation

2.1 The main legislation concerning the safety of nuclear installations is the Health and Safety at Work etc. Act 1974 (HSWA74), the associated relevant statutory provisions of the Nuclear Installations Act 1965 (as amended) (NIA65) and the Ionising Radiations Regulations 1999 (IRR99). Environmental protection is afforded through the regulation of the management of radioactive materials and radioactive waste, for which the principal legislation includes NIA65 and the Radioactive Substances Act, 1993 (as amended by the Environment Act 1995) (RSA93).

Nuclear Installations Act 1965

2.2 Under NIA65 no person may use any site for the purposes of installing or operating a nuclear installation unless a licence so to do has been granted by the HSE and is in force. NIA65 enables HSE to attach conditions to the nuclear site licence in the interest of safety, or which HSE thinks fit with respect to the handling, treatment and disposal of nuclear matter. Once a licence has been issued, the licensee's period of responsibility and the provisions of NIA65 continue to apply throughout operation and decommissioning until, in the opinion of HSE, there has ceased to be any danger from ionising radiations from anything on the site. HSE has delegated its roles under NIA65 to NII. The site licence gives NII a number of powers including the use of consents, approvals, directions, agreements, notifications and specifications. NII will use these powers as appropriate to exercise its regulatory role with respect to licensee's proposals for the management of radioactive materials and radioactive waste.

2.3 The standard conditions associated with nuclear site licences are described in Ref. 1. All the licence conditions apply and are relevant to activities involving the management of radioactive material and radioactive waste. However, the purpose of a number of licence conditions which are particularly relevant to the management of radioactive material and radioactive waste are summarised below:

Licence Condition 4: Restrictions on nuclear matter on the site

The purpose of this LC is to ensure that the licensee carries out its responsibilities to control the introduction and storage of nuclear matter on a licensed site. Nuclear matter being nuclear fuel, radioactive material and radioactive waste.

Licence Condition 6: Documents, records, authorities and certificates

The purpose of this LC is to ensure that adequate records are held by the licensee for a suitable period to demonstrate compliance with licence conditions.

Licence Condition 11: Emergency arrangements

The purpose of this LC is to ensure that the licensee has adequate arrangements in place to respond effectively to any incident ranging from a minor on-site event to a significant release of radioactive material.

Licence Condition 14: Safety documentation

The purpose of this LC is to ensure that the licensee sets up arrangements for the preparation and assessment of the safety related documentation comprising 'safety cases' to ensure that the licensee justifies safety during design, construction, manufacture, commissioning, operation and decommissioning.

Licence Condition 15: Periodic review

The purpose of this LC is to ensure that the plant remains adequately safe and that the safety cases are kept up to date throughout its lifetime. The safety cases should be periodically reviewed in a systematic manner against the original design intent and current safety objectives and practices.

Licence Condition 17: Quality assurance

The purpose of this LC is to ensure that the licensee sets out the managerial and procedural arrangements that will be used to control and monitor those actions necessary in the interests of safety, and to demonstrate compliance with the site licence conditions and any other relevant legislation.

Licence Condition 23: Operating rules

The purpose of this LC is to ensure that all operations that may affect safety are supported by a safety case and that the safety case identifies the conditions and limits that ensure that the plant is kept in a safe condition.

Licence Condition 25: Operational records

The purpose of this LC is to ensure that adequate records are kept regarding operation, inspection and maintenance of any safety-related plant and includes recording the amount and location of all radioactive material, including nuclear fuel and radioactive waste.

Licence Condition 26: Control and supervision of operations

The purpose of this LC is to ensure that safety related operations are carried out only under the control and supervision of suitably qualified and experienced personnel.

Licence Condition 28: Examination, inspection, maintenance and testing

The purpose of this LC is to ensure that all plant that may affect safety is scheduled to receive regular and systematic examination, inspection, maintenance and testing, by and under the control of suitable personnel.

Licence Condition 32: Accumulation of radioactive waste

The purpose of this LC is to ensure that the production rate and accumulation of radioactive waste on the site is minimised, held under suitable storage arrangements and that adequate records are made.

Licence Condition 33: Disposal of radioactive waste

The purpose of this LC is to give discretionary powers to NII to direct that radioactive waste be disposed of in a specified manner. This is related to the similar powers available to the environment agencies under section 30 of RSA93. Such disposals will need to be in accordance with authorisations granted under RSA93.

Licence Condition 34: Leakage and escape of radioactive material and radioactive waste

The purpose of this LC is to ensure, so far as reasonably practicable, that radioactive material and radioactive waste is adequately controlled or contained so as to prevent leaks or escapes, and that any unauthorised leak or escape can be detected and reported.

Licence Condition 35: Decommissioning

The purpose of this LC is to require the licensee to make adequate provisions for decommissioning. It also gives discretionary powers to NII to direct that decommissioning of any plant or process be commenced or halted.

2.4 HSE keeps the licence conditions under review and it will revise them, or add new conditions, as it judges appropriate with respect to its regulatory responsibilities.

Ionising Radiations Regulations 1999

2.5 Requirements for the radiological protection of workers and the public are contained in IRR99. These regulations are enforced on nuclear licensed sites, and on certain Ministry of Defence sites, by NII and on non-licensed sites by other parts of HSE.

Radioactive Substances Act 1993

2.6 Regulation under RSA93 is enforced by the environment agencies, the Environment Agency (EA) in England and Wales, and the Scottish Environment Protection Agency (SEPA) in Scotland. The purpose of RSA93 (sections 6, 7, 13 and 14) is to regulate the keeping and use of radioactive material, to prevent loss to the environment and to control accumulation and disposal of radioactive waste to minimise the impact on the environment. Disposal of radioactive waste includes discharges of aerial and liquid effluent, deposit or burial of solid radioactive waste, and transfer of radioactive waste from a site.

2.7 Licensees of nuclear licensed sites are exempt from RSA93 requirements for an authorisation to accumulate radioactive waste and from registration to keep and use radioactive material (section 8(1)). This exemption does not apply however to an operator of a facility on a licensed site who is not the licensee. In this case, the operator is required to be a registered user of radioactive material. Regulation of the disposal of radioactive waste is the responsibility of the environment agencies. NII has statutory powers under NIA65 for the regulation of the safe management of radioactive material, including radioactive waste, on nuclear licensed sites, prior to disposal, and it consults the views of the environment agencies as required (see section 4 below).

3. Government Policy

3.1 Primary responsibility for civil radioactive waste management policy in the UK lies with the Department of the Environment, Transport and the Regions (DETR) and, as appropriate, the National Assembly for Wales, the Scottish Executive and the Northern Ireland Environment and Heritage Services. The future development of radioactive waste management policy and the regulatory framework is the responsibility of the DETR Radioactive Waste Policy Group of which HSE and the environment agencies are members.

3.2 Government Policy on radioactive waste management was reviewed in 1994/95 and the conclusions of that review were set out in "Review of Radioactive Waste Management Policy, Final Conclusions (Cm 2919)" (Ref. 2). The International Atomic Energy Agency (IAEA), Ref. 3, defines the objective of radioactive waste management as dealing with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations. This objective is reflected in Ref. 2, which states that its primary aim is to ensure that radioactive waste is properly managed and that people and the environment are not exposed to unacceptable risks either now or in the future. Relevant extracts from Ref. 2 are given in Annex 1.

3.3 Following the publication of the report of the House of Lords Select Committee Enquiry into Nuclear Waste Management (Ref. 4), issued in March 1999, the Government has announced a review of this policy which should commence in

2001. This Guidance document will need to be reviewed when the outcome of the review is known to ensure that any developments or changes in policy are reflected. As a result of the Government review, institutional arrangements may change, for example, the role of UK Nirex.

3.4 The OSPAR/Sintra agreement, which the Government signed in July 1998, commits the UK to a progressive and substantial reduction of the radioactivity in liquid discharges by adopting best available techniques, such that additional concentrations in the marine environment above historic levels, are close to zero by 2020. With respect to regulation by HSE and the environment agencies, this agreement may impact on existing disposal routes for routine discharges and result in additional radioactive wastes requiring storage on nuclear licensed sites.

4. The Respective Roles of HSE and the Environment Agencies

4.1 The regulation of radioactive waste management requires close liaison between HSE and the environment agencies due to common interests and the need to regulate in a consistent manner. This section outlines the respective roles of HSE and the environment agencies. It is provided for information to inspectors and is not meant to provide detailed description of the regulatory approach of the environment agencies who are preparing their own guidance.

4.2 Under NIA65, HSE is responsible for regulating operations on a nuclear licensed site. It does this by granting licences to the operators of the sites. Under NIA65, it is able to attach conditions to the licences which it considers necessary or desirable in the interests of safety, covering both normal circumstances, accidents and emergencies. In addition, HSE may attach such conditions it may think fit with respect to the handling, treatment and disposal of nuclear matter (NIA65, section 4(2)). The term nuclear matter includes radioactive material and radioactive waste and these particular conditions can therefore extend to matters other than safety.

4.3 As described in section 2.6, the environment agencies are responsible for regulating, under RSA93, disposals of all forms of radioactive wastes on nuclear licensed sites. The agencies have no statutory powers over waste storage on nuclear licensed sites until the licensee seeks permission to dispose of the waste. On sites that are not licensed, such as hospitals and universities, the agencies regulate storage of radioactive wastes as well as disposals.

4.4 Although HSE and the environment agencies have different statutory powers for the regulation of radioactive waste management at licensed nuclear sites, they work closely to ensure that site licensees are subject to consistent regulatory requirements. NIA65 (as amended by Schedule 22 of the Environment Act 1995) places a requirement on HSE to consult the environment agencies on issues which affect the creation, accumulation or disposal of radioactive waste before issuing, amending or varying nuclear site licences, or attaching conditions to them. In addition to these statutory consultation requirements, the HSE and the EA have set down and jointly agreed their responsibilities and working arrangements on matters of mutual interest within a Memorandum of Understanding (MoU) which is kept under review. A similar MoU is being drawn up between HSE and SEPA. The MoUs are aimed at facilitating effective and consistent regulation of radioactive waste management on nuclear licensed sites and avoiding conflicting requirements being placed on site licensees. For information on their working arrangements, inspectors are advised to consult the guidance given within the MoU.

4.5 HSE and the environment agencies will wish to see that decisions made by licensees on whether/how to retrieve, store, treat, contain and package radioactive wastes have regard to Government Policy, as set out in para 113 of Cm 2919, and take into account all relevant factors. Where activities concern solid radioactive wastes for which there is no current disposal route, the agencies will wish to ensure that waste treatment and packaging activities do not adversely affect the disposability of these wastes.

4.6 The environment agencies are concerned with the effects on the public and the environment arising from radioactivity in the discharges of liquids and gases and solid radioactive waste disposal. Where waste has to be disposed off-site, such disposals will require authorisation by the agencies who will wish to ensure that "Best Practicable Means" (BPM) are being used to mitigate the impact of any such discharges. They will also wish to see that available waste management options have been considered and reasoned arguments presented for the selection of the preferred option, which represents the Best Practical Environmental Option (BPEO).

5. Agreements with Other Organisations

Food Standards Agency

5.1 A working agreement is to be set up between the newly formed Food Standards Agency and HSE to cover areas of common interest, namely, protection of the food chain from radioactive wastes and discharges and the delicensing of nuclear sites.

Ministry of Defence

5.2 MOD and HSE have agreed principles which apply to the MOD's observance of health and safety legislation for both military and civilian employees affected by their activities. These principles apply equally to the management of radioactive materials and radioactive waste and are intended to facilitate inspections, recognising the statutory right of HSE to carry them out under the HSWA in such a way as not to compromise national security and the operational capability of MOD. On sites where a commercial organisation is in significant control of nuclear related work on behalf of MOD, the regulation of nuclear and radiological safety is the duty of NII.

6. Statements of Regulatory Strategy

6.1 This section introduces NII's regulatory strategy to ensure the safe management of radioactive material and radioactive waste on nuclear licensed sites. NII has four fundamental expectations, which should be met so far as is reasonably practicable. These expectations, are as follows:

i) Production of radioactive waste should be avoided. Where radioactive waste is unavoidable, its production should be minimised.

ii) Radioactive material and radioactive waste should be managed safely throughout its life cycle in a manner that is consistent with modern standards.

iii) Full use should be made of existing routes for the disposal of radioactive waste.

iv) Remaining radioactive material and radioactive waste should be put into a passively safe state for interim storage pending future disposal or other long term solution.

6.2 The following statements of regulatory strategy provide general guidance on particular elements of licensees' arrangements that NII will assess to determine the extent to which the above expectations are met:

- strategic planning;
- compatibility with future management and disposal options;
- waste disposal routes;
- safety cases;
- waste minimisation;
- characterisation and segregation;
- passive safe storage;
- timescales for interim storage;
- inspection and retrieval in storage;
- quality assurance;
- records;
- contaminated ground; and
- international standards and developments.

These statements are discussed in turn in the following sections. The attention of inspectors is drawn to the statements that describe recent developments in the regulatory approach including passive safety, timescales for storage and contaminated ground. More detailed guidance appears in the Appendices.

6.3 Strategic Planning

NII requires licensees to undertake strategic planning for the management of all radioactive material and radioactive waste, including the development of programmes for the disposal of waste and the long term management of material which may become waste at some time in the future.

In line with Government Policy, NII requires licensees to produce and maintain a strategy which represents an overview of their approach to the current and future management of radioactive material and radioactive waste. Because of the common interests of HSE and the environment agencies, the licensee should develop the strategy by liaising with the regulatory bodies to avoid unnecessary conflicts and oversights. If a licensee is responsible for a number of nuclear licensed sites, then it may be appropriate for the licensee to produce a corporate strategy supported by a series of site specific strategies.

In selecting a preferred strategy, licensees should demonstrate that a full range of management options have been examined, taking account of all technical factors, social factors, Government Policy and international agreements (for example, OSPAR/Sintra). The reasons for reaching the preferred strategy should be given and major assumptions and uncertainties should be identified together with the approach for their resolution.

The licensee's strategy should identify the inventory of its liabilities and describe the means of managing each waste stream from generation to disposal by practical and cost-effective methods. The strategy should cover the complete life-cycle of the material and associated facilities and should include routine discharges of liquid and gaseous radioactive wastes. The strategy should not be restricted to the consideration of the nuclear matter which licensees currently regard as radioactive waste: it should also cover all radioactive material, including materials held in temporary store prior to operational use, spent fuel, other stocks of fissile and recyclable material and radioactively contaminated ground.

Programmes showing timescales for the management and disposal of radioactive waste should be included and should take account of the current availability or future prospect for disposal routes.

The strategy should describe how the licensee will provide and maintain the arrangements to ensure that the radioactive material and radioactive waste is managed safely until its ultimate disposal, including the provision of an appropriate organisation and supporting infrastructure. Organisational issues and infrastructure requirements in relation to long term waste management are discussed in Appendix 5 of Ref. 5. The strategy should describe how the costs of implementing the strategy have been estimated and how the appropriate funds will be provisioned.

The strategy should be linked to, or integrated with, the strategy for decommissioning of nuclear facilities, including the treatment of radioactively contaminated ground and the ability to dispose of the resulting wastes (see the complementary regulatory guidance, Ref. 5).

The strategy should demonstrate how the requirements of the OSPAR agreement have been taken into account, in particular, the impact on the volume and total activity of on-site waste arisings of solid and liquid wastes, options for storage and ultimate disposal, and implications on compliance with the ALARP principle.

Further guidance on this topic is given in Appendix 2.

6.4 Compatibility with Future Management and Disposal Options

NII expects that licensees manage radioactive material and radioactive waste in a manner that is compatible with future potential disposal requirements and, unless justified on safety grounds, does not unnecessarily foreclose any foreseeable management options.

Radioactive material and radioactive wastes should be managed in a manner which minimises the need for future processing, and that is compatible with anticipated facilities for ultimate disposal or, in the case of radioactive materials, its end-use. The strategies should ensure that waste management problems, which cannot be resolved using current techniques or techniques which could be derived from current lines of development, are not created. Compatibility with future management and disposal requirements is an area where the responsibilities of NII and the environment agencies have significant overlap, including co-ordinating R&D in areas of mutual interest.

In some cases, raw and bulk radioactive waste will require conditioning to place them into a passively safe form to immobilise and contain the radioactive material in discrete quantities. This conditioning should be undertaken as soon as is reasonably practicable. In other cases, the radioactive waste or material may already be in an immobile form (for example, activated steel and concrete) and prompt conditioning may not be required. However, wastes should be stored in discrete quantities which facilitate inspection, monitoring and retrieval and any proposal to delay conditioning into a passively safe state must include a demonstration that such wastes will remain adequately safe in the interim. In general, NII expects licensees to demonstrate that their processing of radioactive waste will not unnecessarily foreclose future management options unless there are worthwhile safety benefits, or if safety is not prejudiced, on economic grounds. This demonstration should address the risk of the waste package being incompatible with future disposal requirements, and the practicability of re-working processed waste should it be necessary. The extent of conditioning and the type of packaging will need to be decided by taking account of all relevant factors. A Letter of Comfort issued by an appropriate organisation, which at the present time is UK Nirex, stating that the processed waste form and its packaging should be acceptable for future potential disposal options, would be an important part of the above demonstration. This assurance should be reviewed periodically to take account of developments of Government Policy, technical developments or institutional changes.

There may be a potential for conflict between the requirement not to foreclose management options with the requirement of achieving passive safety. In such cases, all factors will need to be taken into account and a judgement made that an appropriate balance has been achieved. The Letter of Comfort, and the dialogue between the licensee, the regulators and UK Nirex, will play an essential part in this assessment.

The above demonstration of 'disposability' of wastes is also a responsibility of the environment agencies who are producing their own guidance. A licensee's proposal for a radioactive waste management option cannot proceed without agreement of both HSE and the appropriate environment agency.

6.5 Waste Disposal Routes

NII expects full use to be made of existing routes for the disposal of radioactive waste.

NII expects licensees to dispose of radioactive waste promptly, where there is an available route for disposal. Such disposals will need to be in accordance with an authorisation granted under RSA93 by the environment agencies. The timing of disposal will be subject to the circumstances in each case but, in general, it is expected that, where disposal facilities are available, radioactive waste should be disposed of as soon as is reasonably practicable. Where appropriate, NII has the discretionary power to direct that radioactive waste be disposed of in a specified manner.

6.6 Safety Cases

Licensees are required to provide safety cases demonstrating the safe operation for all the facilities for the management of radioactive material and radioactive waste on the nuclear licensed site. The safety case should justify safe operation for the projected life of the facilities.

Licensees should provide safety case documentation describing their arrangements and justifying safe operation for all the management and storage facilities on the site throughout the projected life of the facilities. The safety case should be consistent with the licensee's strategy for the management of radioactive material.

NII expects the safety case to demonstrate that the design and operation of the facilities, and their associated arrangements, meet legislative requirements (for example, the Licence Conditions). Radioactive material and radioactive waste should be controlled and contained, so far as is reasonably practicable, in a manner that is consistent with modern standards, which are represented by good engineering principles and current best practice. In the case of old facilities, it may not be practicable to back-fit modern standards and any shortfall should be identified and justified. As part of the safety case, licensees should also demonstrate that they are managing radioactive material and radioactive waste in a manner that reduces risk in line with ALARP. Parts of the safety case may be assessed by NII if it decides that it merits it because of the hazards posed or for some other reason. The Safety Assessment Principles (SAPs) (Ref. 6) provide a consistent framework for the assessment of safety cases.

The safety case should be maintained and subjected to periodic review to ensure its continuing validity over the projected life of the facilities. The periodic review should address the impact of any changes in, for example, Government Policy, modern standards and the requirements of other regulators, for example, the environment agencies. Inspectors should ensure that there is sufficient liaison between the regulators and the licensee to avoid conflicts and oversights.

Further guidance on safety cases is given in Appendix 3.

6.7 Waste Minimisation

NII requires licensees to demonstrate that radioactive waste is not unnecessarily created, and that the generation and accumulation of radioactive waste is minimised.

Steps should be taken to avoid the unnecessary creation of radioactive waste and to minimise the production and accumulation of those wastes that are created, in terms of both the activity and volume. Minimising the generation of waste contributes to effective waste management and reduces the risks arising from such waste.

Radioactive waste minimisation should be considered at the design stage for new and modified plant, and during operation and decommissioning, through the application of appropriate strategies and practices. These practices include:

- the optimisation of routine discharges, solid waste arisings, occupational exposure and environmental effects;
- the re-use and recycling of materials;
- decontamination and volume reduction methods; and
- the clearance of material which can be exempted from regulatory control under RSA93.

Further guidance on waste minimisation is given in Appendix 5.

6.8 Characterisation and Segregation

NII requires that, so far as is reasonably practicable, radioactive material and radioactive waste should be characterised and segregated in order to facilitate safe and effective management and disposal.

All existing and future arisings of radioactive material and radioactive waste on site should be identified and characterised (in terms of chemical and physical form, radioactive content, origin, and all other relevant properties).

Segregation of radioactive material and radioactive waste involves accumulating together those materials with similar characteristics, and avoiding mixing those with different characteristics. Segregation is most efficient if it is taken into account at the process design stage. It should be done as close to the point of generation as is reasonably practicable. Early and appropriate segregation can contribute significantly to the effective and safe management of radioactive materials and radioactive waste.

Where it is clear that characterisation and segregation is impractical and not cost effective, the alternative strategy, which should comply with the requirements of the environment agencies, should be justified.

6.9 Passive Safe Storage

NII requires that, so far as is reasonably practicable, radioactive material and radioactive waste should be stored in a passively safe state.

Storage of radioactive material and radioactive waste in conditions of passive safety has significant benefits in terms of safety. Passive safety requires the radioactivity to be immobilised and packaged in a form that is physically and chemically stable. The package should be stored in a manner that is resistant to degradation and hazards, and which minimises the need for control and safety systems, maintenance, monitoring and human intervention.

NII requires that wastes should be placed into a passively safe state as soon as it is reasonably practicable. The more hazardous the waste (for example, HLW) and the more mobile its form, the greater the safety benefit from passively safe storage and the sooner this should be achieved. In circumstances where it is necessary to accumulate potentially mobile wastes in a raw state for significant periods, the safety of the accumulation arrangements will need to be demonstrated.

As noted in section 6.4, there is a potential conflict between the requirement of passive safety and the requirement not to foreclose future options for disposal. In such cases, the management strategy for the particular waste stream needs to be considered on an individual basis, taking account of all factors, to ensure that an appropriate balance is achieved. The licensee needs to address the risk that future disposal options may require the wastes to be reworked into an alternative form and also that reworking may be necessary as a result of deterioration of the packages or accidental damage.

NII has developed a set of engineering principles to describe the features of passive safe storage, which will be achieved by suitable processing of the material, in combination with the design of the container and building. They are summarised below:

- the radioactive material should be immobile;
- the waste package (i.e. the waste form and its container) should be physically and chemically stable;
- potential energy should be removed from the waste;
- containment should be achieved by multiple barriers;
- the waste packages and the building should be resistant to degradation mechanisms;
- the building environment should optimise the life of the waste packages;
- the need for active safety systems, monitoring, maintenance and human intervention to achieve safety should be minimised;
- the waste packages and the building should be resistant to foreseeable hazards;
- access for response to incidents should be provided but the need for prompt remedial action should be minimised;
- provision should be made for the inspection, retrieval and remediation of waste packages;
- the lifetime of the storage arrangements should be appropriate for the storage period; and

- the waste package and the storage system should facilitate final disposal.

These engineering principles apply to new facilities and where existing facilities are to be modified to provide additional storage.

It is expected that licensees will apply the above principles within a framework of reasonable practicability and cost effectiveness. In circumstances where it is not practicable or cost effective to meet all the principles fully, licensees should justify the safety of the proposed alternative.

Further guidance on passive safety is given in Appendix 4.

6.10 Timescales for Interim Storage

For radioactive wastes for which there is presently no disposal route or some other long term option, licensees should plan for a significant period of interim storage.

The refusal to grant planning permission to UK Nirex, for an underground rock characterisation facility near Sellafield, has delayed the availability of a future national disposal facility for ILW (and some forms of LLW which are not suitable for disposal by existing routes). Licensees should, therefore, plan for significant periods of interim storage of these radioactive wastes (and also for materials which may become wastes) until a disposal route becomes available. Thereafter, there will be a need to ensure that the wastes remain in a safe condition for a further significant period, during which wastes from all sites are emplaced in the disposal facility and the disposal facility remains open.

The House of Lords Select Committee on Science and Technology has recently reported on the management of nuclear waste (Ref. 4) where it recommends that '…. *one or more deep repositories are operational in the United Kingdom within about 50 years* ….' The report concludes that '*the preferred approach is phased geological disposal in which wastes are, following surface storage, emplaced in a repository in such a way that they can be monitored and retrieved. The repository would be kept open while data are accumulated, and only closed when there is sufficient confidence to do so*.'

Taking account of these recommendations and, in line with the strategy being developed by UK Nirex, NII proposes that, for radioactive waste and material being placed in storage now, an overall period of containment of at least 150 years should be assumed. This is comprised of the following consecutive periods:

- a period of interim storage of at least 50 years prior to the availability of a disposal facility;
- a period of about 50 years during which the facility is operational and the wastes are emplaced; and
- a further period of at least 50 years during which the facility remains open and waste packages can be retrieved if required.

When the Government review of radioactive waste management policy has been completed, it may be necessary to revise the above scenario, both in terms of the timescales and the long term management option assumed in Ref. 4 i.e. phased geological disposal. Government Policy may be to adopt alternative long term management options which may have an impact on the regulation of radioactive wastes and materials and the period over which it will be necessary to ensure containment.

The requirement to plan for long term interim storage also applies to HLW and spent fuel since there is no available disposal route. In the case of vitrified HLW from reprocessing, the favoured approach (Ref. 2) is deep geological disposal after a cooling period (of about 50 years). For spent fuel, the options are to reprocess or to dry store, prior to the availability of a final disposal route, and this choice is largely a commercial judgement by the operators, subject to satisfying planning and regulatory requirements. The strategy for the long term management of HLW and spent fuel, and research needs, is currently being developed by DETR.

6.11 Inspection and Retrieval in Storage

NII expects that any future storage facilities or modifications to existing facilities should be designed to facilitate inspection, retrieval and remediation of the waste and the facilities.

NII expects the design of new storage facilities to allow for inspection and retrieval. Where existing facilities are to be modified to provide additional storage for an extended period, similar considerations should apply. Facilities should include provision for routine inspection to confirm that the condition of all waste packages and other material and the facilities remain acceptable for future safe management. The design should provide for access to all waste packages, and the ability to retrieve any package in the facility within a reasonable period of time. Facilities should be designed taking account of the potential need to remediate waste packages that have deteriorated.

Further guidance on inspection is given in Appendix 6.

6.12 Quality Assurance

In response to LC 17 (Quality Assurance), licensees are required to develop and implement QA arrangements that cover all relevant phases of their activities e.g. design, construction, manufacture, commissioning, operation and decommissioning.

These arrangements should, as a minimum, encapsulate the requirements of IAEA 50-C-Q series, which in turn cover the principles of ISO 9000 series and BS 5882. In addition, the documented arrangements are expected to include, or at least clearly signpost, the management systems and procedures established to meet all other site licence conditions. A number of licensees have, or are developing, integrated management systems that are designed to meet quality, safety and environmental requirements. Guidance on licensees' arrangements for quality assurance can be found on BMS. Inspection and quality control activities are integral elements of an effective QA programme, particularly as these apply to products and services, for example, waste packaging.

With respect to waste management, licensees are expected to make arrangements for and implement quality control and quality assurance procedures for the processing and packaging of wastes. These arrangements should ensure that waste products comply with relevant specifications, including the Letter of Comfort issued by UK Nirex. These arrangements should cover the procurement of the container and raw materials, the packaging process, the quality of the final product and all necessary records.

6.13 Records

NII requires licensees to make arrangements for recording and preserving all the information that may be required in the future to ensure the safe management of radioactive material and radioactive waste.

Licensees are required to make adequate provision for recording and preserving all the information that may be required in the future to ensure the safe management of radioactive material and radioactive waste, for as long as such information may be required. An approved quality assurance procedure should be adopted to ensure that such records are assembled and maintained in a secure form that is readily auditable and accessible to all those persons who may need to consult them. The records should be comprehensive and include information relating to the radioactive material/waste, plant, buildings and associated structures, including information from the design, construction and operating stages.

Further guidance on this topic is given in Appendix 7.

6.14 Contaminated Ground

NII regards radioactively contaminated ground, or emplaced radioactive material, as an accumulation of radioactive waste and it requires licensees to manage it as such.

The first priority is to prevent radioactive contamination of the ground through control and containment of accumulated radioactive material, and the second priority is to recover any material that has leaked and, if this is not practicable, to contain it. Apart from authorised disposals, NII views radioactively contaminated ground, or emplaced radioactive material, on a nuclear site as an accumulation of radioactive waste. Licensees should manage it as radioactive waste and provide a strategy and safety case for its future management, including final disposal as regulated by the environment agencies under RSA 93. The radioactive waste should be characterised in terms of its location, radioactive content and dispersion.

Further guidance on this topic is given in Appendix 8.

6.15 International Standards and Developments

NII will take into account internationally accepted standards, guidance and practice in assessing the acceptability of licensees' arrangements for the management of radioactive material and radioactive waste.

Where standards or guidance produced by international consensus exist, such as those of IAEA, NII will take these into account in assessing the acceptability of licensees' arrangements for the management of radioactive material and radioactive waste. For example, there is the series of technical reports that are produced by the IAEA on the management of nuclear matter and radioactive waste. In addition, the basic requirements of the IAEA Safety Standard "Establishing a National System for Radioactive Waste Management" (Ref. 7) have been embodied in Government Policy. General radiological protection principles are set out by ICRP (Ref. 8) and their application to radioactive waste disposal is given in Ref. 9. Issues covered include the justification of a practice, the optimisation of protection and the use of collective dose assessed over long distances and times.

NII will also maintain awareness of, and involvement in, national and international developments in the field of radioactive waste management. In order to effectively carry out its responsibilities, NII maintains close involvement with national and international bodies in appropriate fields of waste technology including research and development. This specifically includes maintaining close liaison with DETR, DTI, the environment agencies, the European Commission, IAEA and OECD/NEA.

7. Documentation Structure

7.1 This guidance is structured in the form of a head document describing the framework of legislation, Government Policy and the fundamental principles NII expects to see achieved in the management of radioactive materials and radioactive waste. This is supported by a series of Appendices covering the following specific aspects in more detail:

Appendix 1 Basics of the Management of Radioactive Materials and Radioactive Waste

Appendix 2 Waste Management Strategies

Appendix 3 Safety Cases for Radioactive Waste Management Facilities

Appendix 4 Passive Safety in the Storage of Radioactive Materials and Radioactive Waste

Appendix 5 Radioactive Waste Minimisation

Appendix 6 Inspection of Accumulated and Stored Radioactive Materials and Radioactive Waste

Appendix 7 Records for Radioactive Waste Management and Decommissioning

Appendix 8 Management of Radioactively Contaminated Land

7.2 Inspectors are also referred to the guidance covering decommissioning on nuclear licensed sites (Ref. 5) which has a similar structure of a head document supported by Appendices with the following topic headings:

Appendix 1 Delicensing of Nuclear Sites

Appendix 2 Decommissioning Strategies

Appendix 3 Decommissioning Safety Cases

Appendix 4 Timing of Decommissioning

Appendix 5 Management and Maintenance of an Appropriate Organisation during Decommissioning

Appendix 6 Costs of Radioactive Waste Management and Decommissioning

Appendix 7 Quinquennial Review

8. References

1 Nuclear Site Licences under the Nuclear Installations Act 1965 (as amended) - Notes for Applicants, HSE, 1994.

2 Review of Radioactive Waste Management Policy – Final Conclusions, UK Government Cm 2919, HMSO 1995.

3 IAEA Safety Series No. 111-F, The Principles of Radioactive Waste Management, Vienna, 1995.

4 Management of Nuclear Waste. House of Lords Select Committee on Science and Technology, Third Report. March 1999.

5 Decommissioning on Nuclear Licensed Sites, T/AST/026.

6 Safety Assessment Principles for Nuclear Plants, HSE, NII, 1992.

7 IAEA Safety Series No. 111-S-1, Establishing a National System for Radioactive Waste Management, Vienna, 1995.

8 ICRP Publication 60. 1990 Recommendations of the International Commission on Radiological Protection, 1991.

9 ICRP Publication 77. Radiological protection policy for the disposal of radioactive waste, May 1997.

Annex 1 Extracts from Government White Paper Cm2919 (1995)

Policy Aims

Para 50 Radioactive waste management policy should be based on the same principles as apply more generally to environment policy, and in particular on that of *sustainable development.* Most societies want to achieve economic development to secure higher standards of living, now and for future generations. They also seek to protect and enhance their environment, now and for their children. Sustainable development tries to reconcile these two objectives. A widely quoted definition of this concept is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This principle is outlined at greater length in *Sustainable Development - the UK Strategy* (Cm 2426), which also sets out the following supporting principles:

- decisions should be based on the *best possible scientific information* and analysis of risks;
- where there is uncertainty and potentially serious risk exists, *precautionary* action may be necessary;
- ecological impacts must be considered, particularly where resources are *non-renewable* or effects may be *irreversible*;
- *cost implications* should be brought home directly to the people responsible - the *polluter pays principle*.

Para 51 More specifically, and consistent with the above, radioactive wastes should be managed and disposed of in ways which protect the public, workforce and the environment. The radiation protection principles and criteria adopted in the UK and applied by the regulatory bodies are designed to ensure that there is no unacceptable risk associated with radioactive waste management. In defining these principles and criteria and in their application by the regulators, it is recognised that a point is reached where additional costs of further reduction in risk exceed the benfits arising from the improvements in safety achieved and that the level of safety, and the resources required to achieve it, should not be inconsistent with those accepted in other spheres of human activity.

Para 52 Within the approach outlined in the foregoing two paragraphs:

(1) the *Government* will maintain and continue to develop a policy and regulatory framework which ensure that:

(a) radioactive wastes are not unnecessarily created;

(b) such wastes as are created are safely and appropriately managed and treated;

(c) they are then safely disposed of at appropriate times and in appropriate ways;

so as to safeguard the interest of existing and future generations and the wider environment, and in a manner that commands public confidence and takes due account of costs;

(2) the *regulators,* including in future the Environment Agencies, have the duty to ensure that the framework described above is properly implemented in accordance with their statutory powers;

(3) within that framework, the producers and owners of radioactive wastes are responsible for developing their own waste management strategies, consulting the Government, regulatory bodies and disposal organisations as appropiate. They should ensure that:

(a) they do not create waste management problems which cannot be resolved using current techniques or techniques which could be derived from current lines of development;

(b) where it is practical and cost effective to do so, they characterise and segregate waste on the basis of physical and chemical properties and store in accordance with the principles of passive safety (i.e. the waste is immobilised and the need for maintenance, monitoring or other human intervention is minimised) in order to facilitate safe management and disposal;

(c) they undertake strategic planning, including the development of programmes for the disposal of waste accumulated at nuclear sites within an appropriate time scale and for the decommissioning of redundant plant and facilities. These programmes should be acceptable to the regulators and discussed with them in advance.

The producers and owners of radioactive wastes are responsible for bearing the costs of managing and disposing of the waste, including the costs of regulation and those of related research undertaken both by themselves and by the regulatory bodies. They should cost radioactive waste management and disposal liabilities before these are incurred and make appropriate financial provisions for meeting them. They should regularly review the adequacy of these provisions.

Interim Storage of Intermediate and Low-Level Waste

Para 113 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 will secure worthwhile safety benefits, or worthwhile economic benefits without prejudicing safety, the general presumption against action which might foreclose future management options may be relaxed. The relevant costs and commercial risks must be borne by the owner of the waste. Decisions by operators and regulators will need to have regard to all relevant factors, including the following:

(a) the need for continuing safe storage of the waste, treated and/or contained as necessary;

(b) the benefits of placing waste in a chemically and physically stable form, so that safety may be achieved by passive means;

(c) the risk that treated waste will be incompatible with future disposal requirements and the practicability of re-working treated waste in the future, for disposal or for a period of further storage, should this be necessary;

(d) the state of storage facilities, including the benefits which would be derived from refurbishing or upgrading;

(e) the need to minimise waste degeneration, secondary waste arisings and releases to the environment;

(f) the need to minimise dependence on active safety systems, maintenance, monitoring and human intervention;

(g) the retrievability of the waste for disposal.

Summary of Conclusions

Para 162 The Government has concluded that the policy aims for radioactive waste management should be revised and updated to emphasise the respective roles of Government, regulators and producers and owners of waste, and apply the concept of sustainable development and its supporting principles. Future radioactive waste management policy will be guided by the revised aims set out in paragraph 50 – 52.

Para 179 When 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.

Appendix 1 Basics of the Management of Radioactive Materials and Radioactive Waste

Contents

A1.1 Introduction

A1.1.1 This Appendix presents definitions and descriptions of the basic steps and activities in the management of radioactive material and radioactive waste.

A1.2 Definitions

A1.2.1 The term **nuclear matter**, includes radioactive materials and radioactive waste, and is defined in section 26 of the Nuclear Installations Act 1965 (as amended), as follows:

(a) any fissile material in the form of uranium metal, alloy or chemical compound (including natural uranium), or of plutonium metal, alloy or chemical compound, and any other fissile material which may be prescribed; and

(b) any radioactive material produced in, or made radioactive by exposure to the radiation incidental to, the process of producing or utilising any such fissile material as aforesaid.

(c) any substance which meets the definition of radioactive waste in the Radioactive Substances Act.

A1.2.2 **Radioactive material** is defined in section 1 of the Radioactive Substances Act 1993 as a substance, not being waste, falling within either or both of the following descriptions –

(a) a naturally occurring substance containing an element specified in Schedule 1 of the Act which is present at specific activity levels greater than those given in that Schedule;

(b) any substances which are not naturally occurring, whose radioactivity is wholly or partly due to nuclear fission, neutron or ionising radiation.

A1.2.3 **Radioactive waste** is defined in section 2 of the Radioactive Substances Act 1993 as waste which consists wholly or partly of –

(a) a substance or article which, if it were not waste, would be radioactive material, or

(b) a substance or article which has been contaminated in the course of the production, keeping or use of radioactive material, or by contact with or proximity to other waste falling within paragraph (a) or this paragraph.

A1.2.4 Section 14(4) of RSA93 states that:

".... where radioactive material is produced, kept or used on any premises, and any substance arising from the production, keeping or use of that material is accumulated in a part of the premises appropriated for the purpose, and is retained there for a period of not less than three months, that substance shall, unless the contrary is proved, be presumed –

(a) to be radioactive waste, and

(b) to be accumulated on the premises with a view to subsequent disposal of the substance."

A1.2.5 In the UK, radioactive waste is currently categorised according to its heat generating capacity and its activity content. The categories, given below (from Ref. 1), are based on historical practice and do not prescribe how radioactive waste should be segregated in the future.

High Level or Heat Generating Wastes (HLW)

Wastes in which the temperature may rise significantly as a result of their radioactivity, so that this factor has to be taken into account in designing storage or disposal facilities. IAEA (Ref. 2) guidance is that HLW thermal power exceeds about 2 kW/m^3;

Intermediate Level Wastes (ILW)

Wastes with radioactivity levels exceeding the upper boundaries for low level wastes, but which do not require heating to be taken into account in the design of storage or disposal facilities. IAEA (Ref. 2) guidance is that ILW thermal power is below about 2 kW/m^3;

Low Level Wastes (LLW)

Wastes containing radioactive materials other than those acceptable for disposal with ordinary refuse, but not exceeding 4 GBq/te of alpha or 12 GBq/te beta/gamma activity;

Very Low Level Wastes (VLLW)

Wastes which can be safely disposed of with ordinary refuse (dust-bin disposal), each 0.1 m^3 of material containing less than 400 kBq of beta/gamma activity (4 Bq/cc) or single items containing less than 40 kBq of beta/gamma activity. The categorisation of VLLW is a working practice adopted by the Environment Agency but is not part of the provisions of RSA93.

A1.2.6 The extent of application of regulatory systems to the management of radioactive waste and radioactive materials is described in terms of the concepts of exemption and clearance for which definitions are provided below:

Exemption

A number of 'Exemption Orders' have been made under RSA93 which specify the conditions under which materials or wastes, which are defined as radioactive under the Act, can be made 'Exempt' or excluded from some or all of the provisions of the Act. An important Exemption Order is the Substances of Low Activity Exemption Order (Refs. 3 and 4). This specifies that solid radioactive waste is excluded from the provisions of sections 13(1) and 13(3) of RSA93 provided that it is substantially insoluble in water and has an activity that does not exceed 0.4 Bq/g. These Exemption Orders are currently under review to ensure compliance with European Community Basic Safety Standards (BSS) for protection against the dangers from ionising radiation (Ref. 5).

Clearance

The concept of clearance is intended to describe the process of removal of radioactive materials and their management from within a process of regulatory control. It is particularly relevant to the management of wastes produced in decommissioning. Article 5 of the BSS (Ref. 5) provides guidance on the inventory and concentration of radioactivity below which materials can be removed from regulation. This guidance allows clearance levels to be developed for particular situations, for example, Ref. 6.

A1.3 Basic Steps and Activities in Radioactive Waste Management

A1.3.1 The basic steps in radioactive waste management as described by the IAEA in Refs. 2 and 7 are illustrated in Fig. A1.

Waste Generation occurs during the operational period and during the decommissioning of nuclear facilities. It can be in the form of solid, liquid or gaseous waste.

Pretreatment is the initial step that occurs just after generation. It consists of, for example, collection, segregation, chemical adjustment and decontamination and may include a period of interim storage. This step provides the best opportunity to segregate waste streams, based on similar methods of future management, and to isolate those wastes that are non-radioactive, or those materials which can be recycled.

Treatment involves changing the characteristics of the waste. Basic treatment concepts are volume reduction, radionuclide removal and change of composition. Typical treatment operations include: incineration or compaction of dry solid waste or organic liquid wastes (volume reduction); evaporation, filtration or ion exchange of liquid waste (radionuclide removal); and precipitation or flocculation of chemical species (change of composition).

Conditioning involves those operations that transform radioactive waste into a form suitable for handling, transportation, storage and disposal. These operations may include immobilisation of radioactive waste, placing waste into containers and providing additional packaging. Common immobilisation methods include solidification of LLW and ILW liquid radioactive waste, for example in cement, and vitrification of HLW in a glass matrix. Immobilised waste may be placed in steel drums or other engineered containers to create a waste package.

Storage of radioactive waste may take place between and within the basic radioactive waste management steps. Storage may be used to facilitate the next step or to act as a buffer between and within steps. Periods of storage may extend to many years until the waste is removed from the storage facility for further processing and disposal as applicable. Storage facilities may be co-located with a nuclear power plant or a licensed disposal facility, or may be separate entities. The intention of storage is to isolate the radioactive waste, provide environmental protection and facilitate control.

Retrieval involves the recovery of waste packages from storage either for inspection purposes, for subsequent disposal or further storage in new facilities. Storage facilities may be designed such that the original emplacement equipment may be operated in reverse in order to retrieve waste packages. Others may require the installation of retrieval equipment at the appropriate time.

Disposal consists of the authorised emplacement of packages of radioactive waste in a disposal facility, without the primary intention of **retrieval** and without a need for any further actions to ensure future safety. Disposal may also comprise of discharging radioactive waste (for example, liquid and gaseous effluent into the environment).

A1.3.2 Both in the UK and internationally, Governments continue to favour policies of deep underground disposal. Nirex's current approach is for a phased disposal programme incorporating the concepts of **retrievability** and **reversibility**. Within this approach, a facility would remain in an operational state until a decision is taken at an appropriate time in the future to finally close it. Up to that time, the choice for underground disposal could be reversed and the radioactive wastes retrieved for management in an alternative manner.

A1.3.3 The particular application of each of the basic steps depends on the types of radioactive waste, and the methods of radioactive waste management that are to be employed. In some cases individual steps may be closely linked or carried out together. Conditions for acceptance should be specified for each step of the waste management process to ensure that wastes are managed in a manner that is compatible with the following steps.

A1.3.4 There are a number of activities that are carried out during the management of all types of waste. These are:

Minimisation of waste is fundamental good practice in radioactive waste management. It should be considered during the design of facilities, and applied during all of the basic steps. Waste minimisation is considered further in Appendix 4. Effective methods of minimising the accumulation of radioactive waste include the clearance of waste that is below regulatory control, and the reuse or recycling of radioactive material.

Characterisation of radioactive waste involves determining the physical, chemical and radiological properties. It may be carried out in association with several of the basic steps. It may be required for record keeping, acceptance of waste moving between steps and also to determine the best method of managing waste.

Segregation of radioactive waste involves accumulating together those wastes that have similar physical, chemical and radiological properties and that will be subject to similar methods or options for future management. It also avoids mixing together radioactive wastes that have different properties and different methods of future management. It is most effectively carried out during the early steps of radioactive waste management.

Transportation of radioactive waste may take place between and within the basic steps. The term **transport** generally refers to moving radioactive waste between nuclear sites, whereas **transfer** refers to moving radioactive waste within a nuclear site.

A1.4 References

1 Review of Radioactive Waste Management Policy – Final Conclusions, UK Government Cm 2919, HMSO 1995.

2 IAEA Safety Series No. 111-S-1, Establishing a National System for Radioactive Waste Management, Vienna, 1995.

3 Statutory Instruments, 1986 No.1002, Atomic Energy and Radioactive Substances, The Radioactive Substances (Substances of Low Activity) Exemption Order 1986.

4 Statutory Instruments, 1992 No. 647, Atomic Energy and Radioactive Substances, The Radioactive Substances (Substances of Low Activity) Exemption (Amendment) Order 1992.

5 Basic Safety Standards for the Protection of the Health of Workers and the General Public against the Dangers arising from Ionising Radiation, European Community, Council Directive 96/29/Euratom, L159 Vol 39, June 1996.

6 Recommended Radiological Protection Criteria for the Recycling of Metals from the Dismantling of Nuclear Installations. Radiation Protection Series, No. 89, European Commission, Luxembourg, 1998. ISBN 9282832848.

7 IAEA Safety Fundamentals, Safety Series No.111-F. The Principles of Radioactive Waste Management, Vienna, 1995.

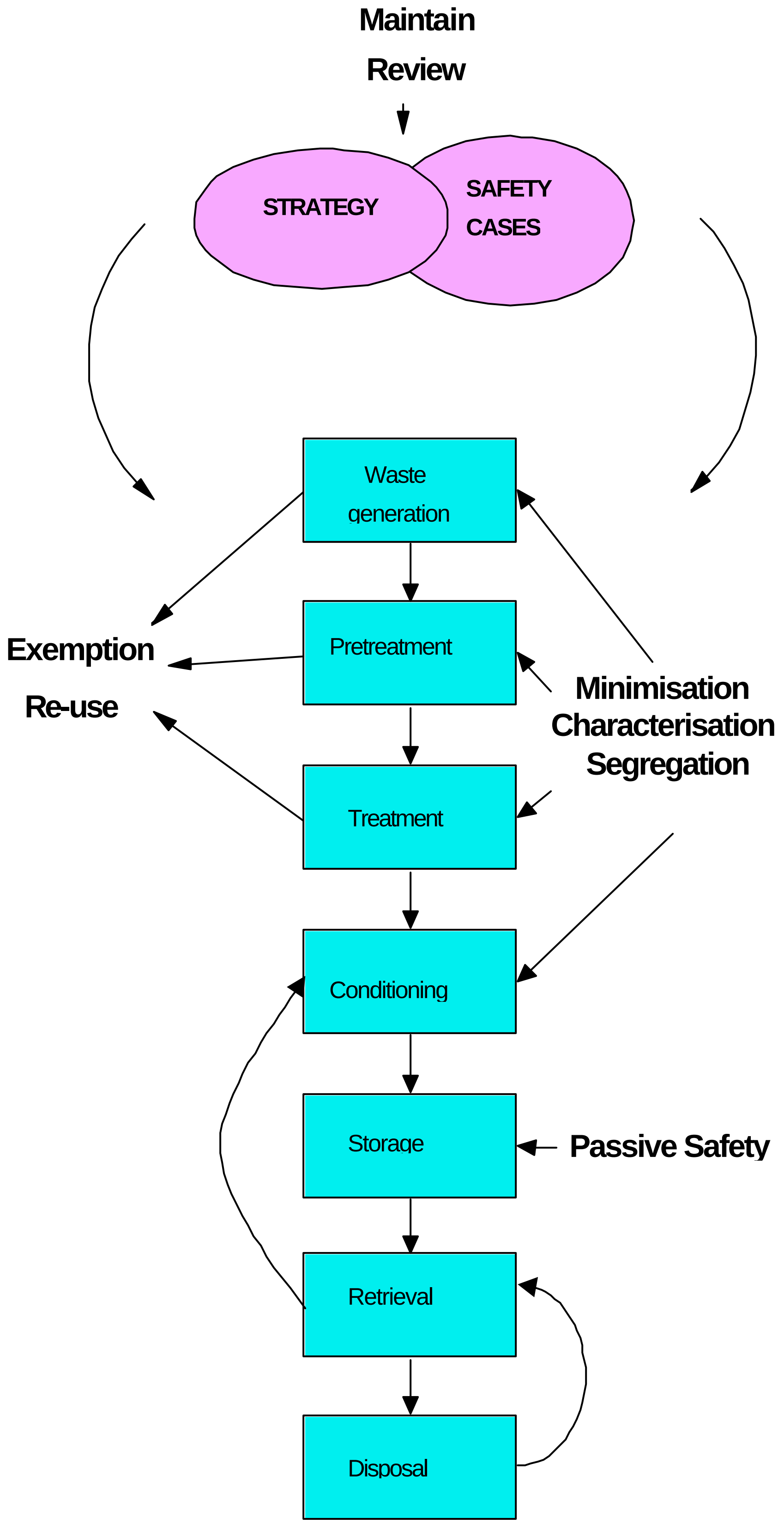

Figure A1 The Basic Steps of Radioactive Waste Management

Appendix 2 Waste Management Strategies

Contents

A2.1 Introduction

A2.1.1 Government Policy states that the producers and owners of radioactive waste are responsible for developing their own waste management strategies. NII requires licensees to produce and maintain a strategy which represents an overview of their approach to the current and future management of radioactive material and radioactive waste. It should cover the complete life-cycle of the material including routine discharges of liquid and gaseous radioactive wastes. The strategy should not be restricted to the consideration of the radioactive material which licensees currently regard as radioactive waste. It should cover all nuclear matter, including materials held in temporary store prior to operational use, spent fuel and other stocks of fissile material which may, at some future time, be reused within the nuclear fuel cycle, but which have the potential to become radioactive waste in the future.

A2.1.2 An additional aspect of Government Policy is that radioactive waste management should be carried out within a framework of sustainable development. A widely quoted definition of this concept is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Issues of relevance to sustainable development are:

- that wastes should be processed as soon as reasonably practicable, into a form which is safe for both the present and the future;
- the storage arrangements should not impose undue responsibilities on future generations to manage the waste;
- the storage arrangements should facilitate retrieval for retreatment if necessary, transfer to other stores and final disposal;
- adequate records should be collected and preserved; and
- provision should be made to cover the future costs of storage and disposal.

A2.2 Guidance on Waste Management Strategies

A2.2.1 A waste management strategy should define a structured approach which is coordinated for individual nuclear facilities on the same or different sites. It should be consistent with the licensee's strategies for decommissioning, and should be regularly reviewed and updated, and take account of changing circumstances. The strategies allow licensees to cost their radioactive waste management and disposal liabilities and make appropriate financial provision for meeting them.

A2.2.2 In selecting a preferred strategy, it is expected that a licensee will follow an approach that ensures that all relevant factors are taken into account. The process should be systematic, comprehensive and transparent. This Appendix does not aim to specify the process that a licensee might follow but to provide guidance on some of the elements that NII would expect to be part of it. The first step in the process is to define and characterise the issue and the associated hazard. The way an issue is framed, and the risks addressed, can have a considerable influence on the judgments that are made.

A2.2.3 A full range of options for managing the issue should be assembled, ranging from doing nothing, reducing the hazard to one that people are prepared to live with, to removing the hazard completely. In looking at options, licensees should establish what represents modern standards for addressing the identified hazard. They should also identify any constraints that may impact on the issue, such as legislation, Government Policy, feasibility, public acceptability, etc. The reasons for excluding options should be recorded. In some cases, there may be more than one option that is consistent with modern standards and the constraints.

A2.2.4 Licensees should establish the range of risks and detriments that are associated with the options. These will include risks to the environment, public and workers and societal concerns as well as the cost to the licensee. They should use a transparent process for selecting their preferred option and for demonstrating how the relevant factors have been taken into account. Assumptions should be recorded and uncertainties should be identified and addressed.

A2.2.5 The manner and form in which they choose to prepare, maintain and document the information relating to their strategies is a matter for the licensees. It is not the aim of this guidance to be prescriptive, but strategies are expected to contain the following elements:

- Descriptions of:
    - the licensee's radioactive waste management objectives and policy;
    - the current and future inventory of radioactive waste;
    - the preferred option for managing each waste stream throughout its life cycle to disposal including programmes showing timescales, methods, proposed disposal route, fallback options;
    - the justification of the preferred option including the alternative options examined, the selection factors taken into account, major assumptions and the availability of disposal routes; and
    - how the balance between foreclosure of disposal options and passive safety has been addressed and resolved.
- Demonstration of consistency with Government Policy and NII's fundamental expectations for radioactive waste management.
- Significant uncertainties should be identified, the impact assessed and the approach for resolution described.
- Results of analyses to assess the sensitivity of the selection of the preferred option to assumptions, uncertainties and factors.

- Approach to ensuring safety.
- Corporate arrangements and infrastructure for continuing capability to meet licensee responsibilities.
- The costs of implementing the strategy and provisioning for future activities.

Appendix 3 Safety Cases for Radioactive Waste Management Facilities

Contents

A3.1 Introduction

A3.1.1 NII requires licensees to provide safety cases demonstrating the safe operation of all their facilities including those used for the management of radioactive material and radioactive waste. General guidance on the content of safety cases for all types of nuclear facilities is available to inspectors in Ref. 1. This appendix aims to focus on a series of important issues that are particularly relevant to radioactive waste management facilities, which need to be addressed in the safety cases.

A3.1.2 It is generally accepted that radioactive waste management is an area where there is significant societal concern and for which the public expects high standards to be applied. Lack of progress in the development of a disposal facility for much of the UK's radioactive waste, means that radioactive waste management facilities will be required to operate safely for very long periods of time into the future. In some cases radioactive waste management facilities are new, but in many other cases the plants were built a long time ago to different standards. Some of the historical plants remain in a good condition but others may be physically deteriorating. All these issues need to be considered in developing an acceptable safety case.

A3.1.3 A safety case should demonstrate that the design and operation of the facilities and their associated arrangements meet modern standards, legislation and Government policy, and then that the remaining risks have been reduced ALARP. This approach of demonstrating a robust engineering design and use of current best practice is fundamental to the demonstration of safety. Quantified risk assessment (QRA) can help to prioritise safety issues and to investigate the benefits of further safety improvements, but they can incorporate a high level of uncertainty. For this reason, it is NII's view that the calculated risk estimates for radioactive waste management facilities, which often produce low numbers, should be treated with caution and they should never be used to justify poor practice.

A3.1.4 Further guidance on regulatory policy, the content of safety cases, modern standards, the use of QRA and the approach to new and existing plant is given in the following sections.

A3.2 Regulatory Policy

A3.2.1 HSC's policy statements (Ref. 2) on enforcement require NII to regulate in a manner that is informed by the principle of proportionality in applying the law and securing compliance. The concept of proportionality is built into the regulatory system and involves deciding what is reasonably practicable to control risks, and recognises that protective measures should take account of cost as well as the degree of risk. HSC states that it may be legitimately expected that relevant good practice will be followed. Where good practice is not established, duty holders are required to assess the significance of the risks and to determine what action should be taken to counter them.

A3.2.2 HSE guidelines on the tolerability of risk were first laid down in TOR (Ref. 3), and have been updated in R2P2 (Ref. 4). The latter document emphasises the need to address the hazard itself as well as the risk that it represents, and has introduced societal concern as an additional factor in judging whether risks have been reduced to an acceptable level. It is particularly relevant to radioactive waste management and decommissioning projects where there is significant societal concern.

A3.2.3 HSE's evidence to the House of Lords Select Committee on Science and Technology: Enquiry on the Management of Nuclear Waste (Ref. 5) provides a clear statement of NII's view that the normal approach to ensuring safety is to rely on robust engineering design and defence in depth, and that probabilistic risk assessments may be used to judge the significance of uncertainties.

A3.2.4 R2P2 introduces the **precautionary principle** which describes the philosophy that should be adopted for addressing potentially serious risks subject to high scientific uncertainty, particularly in the environmental field, and where there are risks that could affect future generations. As uncertainty increases, then more emphasis should be placed on reducing the hazard by cost-effective means. The best approach to satisfying the precautionary principle is, firstly, to consider those alternatives that will avoid the hazard in the first place and, secondly, to implement measures to significantly reduce it. Again this principle is particularly appropriate to radioactive waste management and decommissioning projects.

A3.3 Licence Conditions and Safety Assessment Principles

A3.3.1 LC14 requires licensees to make and implement arrangements for the production of safety cases and LC23 requires licensees to produce an adequate safety case for any operation that may affect safety. The safety case for the management of radioactive waste, and the associated facilities, will be one part of the overall safety case for any nuclear site. The safety case should justify safe operation throughout the projected life of the facilities, and LC15 requires the licensee to implement arrangements for the periodic and systematic review of safety cases to ensure their continuing validity.

A3.3.2 NII's SAPs, which have the status of guidance, form a framework for a consistent approach to the assessment of licensee's safety cases. They represent NII's view of current good engineering principles and NII expects modern plant to have no difficulty in satisfying them. Not all of the principles are relevant to every plant, but the extent to which the relevant principles are met is an important factor in making decisions on the acceptability of a plant. Last published in 1992, the SAPs are currently being reviewed by NII and this guidance will inform the update.

A3.3.3 It is not possible to define the relevant SAPs for any particular plant but, in the spirit of guidance, the following SAPs will be important for assessing a safety case for the management of radioactive material and radioactive waste: Key Principles (P61 and P76), Categorisation, Codes and principles (P82), Containment and Ventilation (P223, P230, P231 and P233), Control of Nuclear Matter (P281), Radioactive Wastes (P294 - P307), Radioactive Scrap (P308), and Nuclear Matter (P309 - P314). In addition, P65 introduces the concept of Defence in Depth and the need to provide multiple physical barriers to the release of radioactive materials to the environment.

A3.4 Content of Safety Cases

A3.4.1 A plant safety case comprises a suite of safety documentation which, when taken together, justifies the safety of the plant throughout its life. Because the operations and activities on a site change with time, the safety case needs to be regularly reviewed and updated to ensure that the safety significance of the changes are reflected. The specification of the format and content of a safety case is a licensee's responsibility.

A3.4.2 Inspectors are referred to the detailed guidance on NII's expectations for the content of safety cases for all types of nuclear facilities which is given in Ref. 1. This section lists below certain elements that are particularly relevant to safety cases for radioactive waste management facilities, it is not a comprehensive contents list for a safety case.

- Descriptions of the facilities, environment and processes including:
  - the buildings and plant;
  - site conditions;
  - the waste streams (their characteristics and quantities); and
  - the waste management processes (see section A3.4.3).
- Consistency with radioactive waste management and decommissioning strategies.
- Identification of modern standards and best practice.
- Demonstration that radioactive material and radioactive waste is adequately controlled and contained.
- Operational procedures including:
  - operating instructions;
  - relevant limits, rules and conditions for operation; and

- inspection, maintenance and monitoring schedules.

- Demonstration that the plant:

  - is fit for purpose;
  - is consistent with good engineering and best practice;
  - provides adequate safety throughout its proposed life; and
  - that risks are reduced ALARP.

- That the ageing of structures, plant and waste packages is adequately managed.

A3.4.3 The means of management of the wastes will be specific to a particular plant but, in accordance with LCs 32, 33 and 34, will include the arrangements for accumulation, disposal, controlling and containing radioactive waste, and the means for detecting leaks. The processes described will include those for waste minimisation, segregation, characterisation, containment, treatment, packaging, retrieval, and transport. In addition, the management of ageing of structures, systems and waste packages throughout the life of the plant needs to be described, including the identification of relevant degradation mechanisms.

A3.5 Modern Standards

A3.5.1 Modern standards are represented by good engineering principles and current best practice which represent, in effect, a consensus between regulators, technical experts, licensees etc. as to what constitutes proportionate action to control a given hazard (Ref. 4) and a tolerable level of residual risk taking account of what is technically feasible, the balance of costs and benefits and other factors such as alleviating public concern. For any particular application, the licensee and the regulator should agree upon the modern standards to be applied.

A3.5.2 Several authoritative sources of modern standards exist:

i) Prescriptive legislation.
ii) HSC/E ACoPs.
iii) Guidance from HSC/E and Other Government Departments.
iv) Standards produced by Standards-making organisations.
v) Guidance agreed by an organisation representing a particular sector of industry.
vi) Standard practice adopted by a particular sector of industry.

A3.5.3 There is a reduction, from (i) downwards in the above list, in the degree of authority implied and hence the mandatory compliance required. Formal standards exist for many engineering and operational features. There are several international bodies, which produce standards or guidance documents: for example the documentation from the IAEA, which is developed by international consensus, and which the UK generally use as the basis for requirements. Some licensees have established their own standards.

A3.5.4 Another important source of good practice in the nuclear industry is what is done, or has been done, on similar plants. Guidance at (v) and (vi) is likely to be wider in scope, more detailed and more directly applicable to practical situations and should not be regarded as less important than other sources. However, in invoking past practices, it is important to be clear that they are still relevant, were implemented for safety reasons and represent current best practice.

A3.5.5 Modern standards, in the form of good engineering principles and current best practice, will continue to evolve with time as a result of research and development, operational experience, safety considerations, Government Policy and public opinion. In addition, the balance of what is considered to be reasonably practicable can change with time.

A3.6 Demonstration of ALARP

A3.6.1 NII expects licensees to demonstrate that the risks associated with operations have been reduced ALARP. This generally involves identifying further risk reduction measures, assessing the risk reduction they achieve, and comparing this with the cost of implementation in order to determine whether they are reasonably practicable or not. TOR (Ref. 3) describes the three zones of risk: the "intolerable region", where the risk from an activity is so high that it is intolerable and the activity is unacceptable and cannot be justified except in extraordinary circumstances; the "ALARP region"; where the licensee must demonstrate that, for whatever reason, it is not reasonably practicable to reduce the risk associated with an activity further, and the "broadly acceptable region", where there is no need for detailed working to demonstrate ALARP.

A3.6.2 Licensees may use probabilistic safety assessment (PSA) or quantitative risk assessment (QRA) techniques to produce numerical estimates of the risk from a facility. PSA can be used to review and confirm the level of safety afforded by plant design, and it can be used to identify and prioritise safety issues. The estimated risk may be compared with quantitative targets, such as those defined in TOR (Ref. 3), and surrogate targets given in the SAPs. The benefits of risk reduction can be valued in monetary terms and compared with the costs of the improvement measures using Cost Benefit Analysis (CBA) in order to judge whether they are reasonably practicable.

A3.6.3 There are a number of concerns with respect to the use of PSA in addressing the risk from radioactive waste management activities. Assessments of the risk from such facilities can result in very low values, in which case, a high level of confidence in the engineering standards is required if the estimates are to be justified. For very long term activities, such as passive safe storage and decommissioning, risk should be assessed in an integrated manner, not restricted to only part of the overall time period or part of the plant. Appropriate account should be taken of the potential areas of uncertainty, which may include, for example:

i) the long term integrity of containment structures;
ii) inaccuracies associated with quantification of risk;
iii) long time periods into the future;
iv) imprecise inventories of nuclear facilities;
v) consequences of leakage to ground; and
vi) consequences of any future remedial or retrieval operations.

Other concerns in over-reliance on the use of PSA/CBA include:

i) misrepresenting issues as being primarily ones of risk;
ii) undermining a precautionary approach;
iii) identifying and taking account of the whole range of benefits and detriments;
iv) dealing with uncertainties; and
v) the difficulty in assigning monetary value to all factors.

A3.6.4 The inappropriate consideration of quantitative factors may lead to conclusions that argue against design features that consideration of sound engineering principles demand. It is therefore important to emphasise that PSA should not be used to override modern standards or justify poor engineering practice.

A3.7 Application to Existing Plant

A3.7.1 In some instances licensees may choose to provide new facilities for radioactive waste management, in which case the new plant are expected to meet modern standards. However, in other instances licensees may choose to use existing facilities, in some cases modified, for radioactive waste management. The consideration of the safety of older plant requires a high degree of engineering judgement. This judgement will need to take account of the current and future condition of the plant, and the intended use, in order to determine whether it is adequately safe and fit for purpose.

A3.7.2 A standard approach for justifying the safe operation of existing plants is described in Ref. 6. In summary it is to: define the modern standards, good engineering principles and current practice that apply, establish the shortfalls in the plant and to investigate what safety improvements are reasonably practicable. The justification of reasonable practicability should take account of the age and projected future life of the facilities. It may be possible to demonstrate that the shortfalls in such facilities, compared to modern standards, are acceptable for the specified usage. For deteriorating plant it may be necessary to specify plant modifications and increased monitoring to provide confidence in their safety. A particular concern about the acceptability of existing facilities that fail to meet current modern standards, for long term future use, is the probability that they would fall further behind modern standards in the future.

A3.7.3 Licensees may wish to use temporary facilities for radioactive waste management to support other processes, for example decommissioning, retrieval of radioactive waste for disposal or passive safe storage, or pending construction of other facilities. In these cases licensees should demonstrate that the temporary facilities are fit for purpose and that there is a net benefit from their use. NII would expect such arrangements to be truly temporary and required for relatively short periods of time such as weeks, months or at most one or two years. If such arrangements are required for longer time periods then they cannot be regarded as temporary.

A3.8 References

1 Guidance on the Purpose, Scope and Content of Nuclear Safety Cases. Draft in preparation.

2 Health and Safety Commission. Enforcement Policy Statement. October 1995.

3 The Tolerability of Risk from Nuclear Power Stations, HSE, 1992.

4 Reducing Risks, Protecting People, HSE Discussion Document, December 1998.

5 Evidence from the HSE to the House of Lords Select Committee on Science and Technology: Enquiry on the Management of Nuclear Waste, January 1998.

6 Evaluation of the Safety of Operating Nuclear Power Plants built to earlier Standards: A common basis for judgement, IAEA Safety Series Report No 12.

Appendix 4 Passive Safety in the Storage of Radioactive Materials and Radioactive Waste

Contents

A4.1 Introduction

A4.1.1 One of NII's fundamental expectations is that, so far as is reasonably practicable, radioactive materials and radioactive waste should be stored according to the principles of passive safety. The more hazardous the waste (for example, HLW) and the more mobile its form, the greater the safety benefit from passively safe storage and the sooner this should be achieved. Only when this is not reasonably practicable, should potentially mobile wastes be accumulated in a raw state for significant periods.

A4.1.2 Passive safety, which is an element of Government Policy (Ref. 1), requires the radioactive wastes and materials to be immobilised in a form that is physically and chemically stable and stored in a manner which minimises the need for control and safety systems, maintenance, monitoring and human intervention. The wastes and materials should be stored in discrete packages which are resistant to degradation and hazards and which can be inspected and retrieved for final disposal.

A4.1.3 The refusal to grant planning permission to UK Nirex for an underground rock characterisation facility near Sellafield, has delayed the availability of a future disposal facility for ILW and LLW. As explained in section 6.10 of the head document, this has resulted in the need to ensure that waste packages remain in a safe condition for a period of at least 150 years. The passive safe storage of radioactive materials and radioactive waste has potential long term safety benefits which clearly help to achieve this requirement.

A4.1.4 As explained in section 6.4 of the head document, achieving passive safety in practice potentially conflicts with the requirement not to foreclose management options. In such cases, the benefits of processing material to achieve passive safety need to be balanced against any disbenefits on a case-by-case basis. The environment agencies should be consulted on issues that may impact on the final disposal.

A4.2 Licence Conditions and Safety Assessment Principles

A4.2.1 All the licence conditions which are concerned with the management of radioactive material and radioactive waste are relevant to passive safe storage. LC34, which requires the licensee to control or contain radioactive material and radioactive waste at all times, is particularly relevant. Storing radioactive materials and radioactive wastes in a passively safe form is an important means whereby a licensee may comply with this condition, particularly where storage periods are potentially very long.

A4.2.2 SAP P61 describes the concept of passive safety i.e. that, where appropriate, safe conditions can be maintained through a design that does not require reliance on control or safety systems. SAP P65 introduces the concept of defence in depth as a means of mitigating the consequences of faults or failures. The SAPs that deal with radioactive wastes, radioactive scrap and the storage of nuclear matter, do not explicitly refer to passive safety, but their expectations are relevant to the assessment of the application of passive safety to the storage of radioactive material.

A4.3 The Achievement of Passive Safety

A4.3.1 Passive safe storage of radioactive materials and radioactive waste is most appropriately achieved by providing multiple physical barriers to the release of radioactivity to the environment. The physical barriers include the form of the waste or material itself, the material used for encapsulation, the waste container and the storage building or structure, each of which should be designed to provide effective containment and prevent leakage.

A4.3.2 In its strictest sense, passive safety requires that safety is assured without dependence on active systems, maintenance, monitoring or human intervention. However, with respect to the long term storage of radioactive waste, it may be necessary or advantageous for active systems to be in place. In such cases, the systems should be designed for minimum maintenance and, in the event of failure, immediate repair/replacement should not be necessary in order to ensure continuing safety of the storage facility and its contents. A possible example of this is the ventilation system of a storage facility (see section A4.3.5.4). The extent to which passive safety is required will need to be determined by a balance between the factors discussed in the remainder of this section (for example, safety, best practices, protection of the wastes, cost, sustainability etc.).

A4.3.3 <u>Form of the Radioactive Material and/or Radioactive Waste</u>

A4.3.3.1 The primary consideration is to ensure that the radioactive material or radioactive waste is immobile and is contained in order to minimise the potential for dispersal. The radioactive material or waste should therefore be in a form which is physically and chemically stable and should also be resistant to any significant deterioration over the storage period.

A4.3.3.2 Certain raw radioactive wastes may be in a form for which the radioactivity is already immobile and therefore meet the requirements for passive safety without the need for processing. Such cases will require to be demonstrated, but examples could include robust metallic components.

A4.3.3.3 In many cases, the raw radioactive material or radioactive waste will require conditioning to place it into a passively safe form to immobilise the radioactivity. Typical waste forms that fall into this category are gases, liquids, wet solids, slurries, sludges, powders, particulate material, bulk material and radioactive materials including spent fuel. The conditioning processes that are typically used for immobilisation of liquids and solids are encapsulation in cement or vitrification.

A4.3.3.4 Other raw radioactive wastes may be in a form for which some intermediate processing may be required prior to conversion into a passive safe form. For example, highly reactive or corrosive substances should be neutralised or made less reactive by chemical processes. In the few cases where a raw radioactive waste is not suitable for processing, then these wastes should be identified and an acceptable alternative strategy for their future management developed.

A4.3.3.5 The particular properties that can be expected to be met by a passively safe form of radioactive waste or radioactive material are:

- Stored potential energy should, as far as possible, have been removed from the system. This can arise from, for example, the effects of gravity, chemical energy, water pressure, internal pressure and Wigner energy (graphite).

- The form of the material or waste should have low chemical reactivity, for example, low solubility, low flammability, not be explosive and not need inerting.

- Where the waste or material is known to generate gases, the packaging should include provision for venting.

- The form of the material or waste should be resistant to degradation over the period of storage. Potential mechanisms include corrosion, action of water and microbiological action.

- The form of the material or waste should not require cooling other than by natural circulation.

A4.3.3.6 A passively safe form of radioactive material or radioactive waste should be resistant to dispersion as a result of the range of foreseeable internal or external hazards. This property is covered in section A4.3.6.

A4.3.3.7 In general, it should be possible to process radioactive waste in a manner that minimises the need for future handling and processing, and that is compatible with anticipated requirements for disposal. However, Government Policy is that, where there are worthwhile safety benefits to be gained, the management of radioactive waste for passive safety should not be unduly constrained by the possible requirements for final disposal which may be many decades into the future. Decisions will need to have regard to all relevant factors including those related to safety and the environment, the risk that the treated waste will be incompatible with future disposal requirements, the practicality of reworking treated waste (if required), the need to minimise the dependence on active safety systems, maintenance and monitoring and the retrievability of wastes for final disposal.

A4.3.3.8 UK Nirex has prepared its own guidance on waste form properties, to assist radioactive waste producers who are conditioning waste. Although the guidance is aimed at the preparation of radioactive waste for transport and final disposal in a repository, in general, the criteria are consistent with the achievement of passive safety during interim storage. The guidance presents criteria for the following properties of the conditioned waste form: the immobilisation of radioactivity; resistance to hazards; mechanical and physical properties; chemical properties; degradation processes; gas generation; dose rate; and criticality.

A4.3.3.9 NII will expect licensees to address the potential impact of processing radioactive waste for passive safety on the foreseeable management options, including the risk that the waste form will be incompatible with future disposal requirements. An important part of that demonstration will be a Letter of Comfort, issued by an appropriate organisation, stating that the final waste form should be acceptable for future disposal. Under present institutional arrangements, the appropriate organisation is UK Nirex. However, one of the recommendations of the House of Lords Select Committee (Ref. 2), is that the role of UK Nirex should change.

A4.3.4 <u>The Waste Container and Encapsulation Material</u>

A4.3.4.1 In order to contribute to passive safety the container should have attributes similar to those already identified for the form of the material or waste. It should be resistant to degradation over the period of storage and should be resistant to the range of foreseeable internal or external hazards, as covered in section A4.3.6, to an extent that neither the containment function or the ability of the container to be handled safely are significantly impaired.

A4.3.4.2 In general, the waste package (i.e. the waste form, the encapsulation material and the container) should be designed to be suitable for long term storage, transport and potential final disposal of the waste. This will minimise the amount of reworking prior to disposal.

A4.3.4.3 UK Nirex has prepared its own guidance on the design of a number of standard packages, to assist radioactive waste producers who are managing radioactive waste. The guidance includes quality assurance requirements, dimensional criteria of the containers and performance criteria of the packages. The criteria include: activity content; dose rates; heat output; surface contamination; dimensions; lifting feature; mass; venting; integrity; properties of the waste form; impact strength; fire performance; stackability; and identification. These criteria take into account the range of waste forms for which containers are designed to provide containment. In general terms, these criteria are consistent with passive safe storage.

A4.3.4.4 Waste packages should be uniquely identifiable via appropriate labeling. The method of labeling should be designed to ensure identification over the expected period and conditions of passive safe storage. UK Nirex has also developed guidance on the labeling of waste packages.

A4.3.4.5 Before being placed in storage, waste packages should have been monitored and cleared for the presence of surface contamination which could otherwise initiate or accelerate corrosion of the package. Suitable arrangements should be available for dealing with any surface contamination that is found.

A4.3.5 Storage Building or Structure

A4.3.5.1 The storage building or structure is the final physical barrier to the release of radioactivity to the environment. It is noted however, that in aiming to achieve passive safety the most significant barriers are first and foremost the waste form itself, and secondly the waste container. In some cases, the role of the storage building or structure may be limited to providing environmental protection, radiation shielding and presenting a secure boundary against unauthorised intrusion or interference and entry of wildlife.

A4.3.5.2 The licensee should demonstrate that the design of the storage building or structure is fit for purpose, taking account of the expected time required for passive safe storage and the hazards posed by the stored wastes i.e. the design should be proportionate to the defined purpose of the building and to the risks. Some licensees propose to use existing structures, modified in some cases, for future long-term storage. In these cases, it should be demonstrated that, so far as is reasonably practicable, the structure meets current standards and is safe for the projected period of storage. In some cases, a building may be designed for a shorter life with the intention of periodic refurbishment. In these cases, justification should be provided that the waste can be stored safely while the refurbishment is carried out.

A4.3.5.3 The building should be designed to be resistant to the range of foreseeable internal and external hazards as described in section A4.3.6.

A4.3.5.4 The storage building will need to provide sufficient protection to the stored wastes so as to optimise the life of the packages and to facilitate safe transfer to the final disposal facility (or to a further storage facility) at the appropriate time. This may necessitate control and monitoring of the environment of the storage building (temperature, relative humidity and constituents of the atmosphere) and also of the surface temperature of the waste packages in order to minimise corrosion rates. This may be particularly important on near coastal sites where chloride levels in the atmosphere are relatively high. Such environmental control cannot be achieved by purely passive means and it may be necessary to adopt a forced ventilation system with control of relative humidity and a filtered inlet to remove atmospheric contaminants such as salts. As noted in section A4.3.2, this is an example of where there may be a need for an active system as opposed to a passive system. Current practice is that such systems are very reliable, simple, long lived and easily maintained. Provision for detecting, collecting and removing any water ingress will also be required (see para A4.3.5.9).

A4.3.5.5 Monitoring systems and alarms will need to be provided to detect off-normal conditions such as off-normal temperature and relative humidity in the atmosphere of the facility, build up of flammable gases, water ingress, fires and unauthorised intrusion. A radiation monitoring system would provide the ability to detect radioactivity in liquid or gaseous forms in the event of damaged/deteriorated packages. Groundwater should also be routinely monitored. Wherever possible, the panels and electronics associated with the monitoring system should be situated in a safe area of the building or externally.

A4.3.5.6 Means should be included for the retrieval of a faulty package and for additional processing to render it safe for ongoing storage.

A4.3.5.7 The design of the building should facilitate the retrieval of all waste packages either for inspection, possible remedial treatment, further storage elsewhere or for disposal at the end of the period of passive safe storage or at an earlier time should radioactive waste management strategies change. Waste handling equipment may not be continuously available, but should be capable of being returned to service when needed and should be maintainable within a safe area either inside or external to the building. Depending on the radiation levels associated with the waste packages, remote or manual handling techniques will be necessary.

A4.3.5.8 The need for surveillance and inspection of the waste packages and of the building to ensure safety should be minimised. It would, however, be good practice to provide periodic surveillance and inspection to confirm that the condition of the waste and its storage are not deteriorating. The building design should include provision for routine inspection, including access to all the packages by remote or manual means depending on the radiation levels, and the ability to retrieve packages for inspection and remedial action. There may be benefit to be gained from including the facility for members of the public to view the waste for reassurance purposes.

A4.3.5.9 One of the foreseeable mechanisms for the mobilisation of radioactivity in waste is the ingress and action of water in a store. Potential sources of water ingress are groundwater, rainwater, flooding and condensation. An effective means of reducing potential water ingress is to situate the storage building above ground level. If a building is below ground level then it is best situated above the local water table. In general, it can be expected that the design of a storage building will include features to monitor for water ingress and the means to remove the water. These features could involve a sloping floor, collection sump with level alarm and safe facilities to pump out water and monitor for radioactivity prior to authorised disposal.

A4.3.5.10 The need for human involvement to ensure safety should be minimised. Ideally, no continuous human presence or supervision should be required. Human involvement should be limited to confirmatory surveillance, inspections and responding to incidents on a reasonable timescale.

A4.3.6 Hazards

A4.3.6.1 The multiple physical barriers to the release of radioactivity from the waste should provide resistance to dispersal as a result of a range of foreseeable external and internal hazards. SAPs P72 and P119 - P143 cover the assessment of safety with respect to external and internal hazards and guidance to inspectors is given in other NII assessment guides.

A4.3.6.2 Although specific guidance on hazards is available (Refs. 3 and 4), some issues relevant to passive safety are noted here. Any hazards, which could cause deterioration of the waste form, container or building over the storage period, should be taken into account including, for example, corrosion, water or microbiological action. For external hazards, such as weather and flooding, account should be taken of long term trends such as rising sea level or climatic change. The waste itself may be the source of hazards, in that it may have the potential for criticality or radiolytic gas generation.

A4.3.6.3 The design of the storage arrangements should aim to minimise the requirement for prompt remedial action following events, to mitigate the release of radioactivity.

A4.3.7 Records

A4.3.7.1 The interim storage of radioactive waste in a passive safe form may last for a period of more than 150 years before the disposal facility is closed. Comprehensive records need to be assembled as part of the storage arrangements. They need to be securely retained and to be accessible when required. Inspectors are referred to Appendix 7 for guidance on records.

A4.3.8 Radiation Shielding

A4.3.8.1 Adequate shielding of operators and the public against the radiation hazard from the radioactivity in the waste should be provided by a combination of the waste form, the waste container and the storage building or structure.

A4.3.9 Radioactive Discharges

A4.3.9.1 If the long term storage of radioactive waste will involve the discharge of radioactivity to the environment, for example, gaseous discharges may occur via ventilation systems and liquid discharges may occur from systems designed to maintain dry conditions in the store, then such disposals will require authorisation by the environment agencies under the RSA93.

A4.3.9.2 Provision should be made for mitigating the release of radioactivity from the facility in the event of off-normal conditions, for example, by filtration or isolation.

A4.3.10 Timescale for the Implementation of Passive Safety

A4.3.10.1 The implementation of the passive safe storage of radioactive wastes should be achieved as soon as reasonably practicable. The maximum period of benefit from passive safe storage will be achieved by the earliest implementation and therefore any delay should be justified. Factors that could influence the timing of the implementation of passive safe storage are:

- the magnitude of the radioactive hazard;
- the current form of the waste;
- the safety of the current facilities for accumulating raw waste;
- the rate of deterioration of the facilities;
- the rate of deterioration of the waste;
- uncertainty in knowledge of the waste;
- continuing waste arisings;
- integration with decommissioning plans;

- radioactive decay or ingrowth; and
- the availability of a disposal route.

A4.3.10.2 HLW in a liquid form represents a significant hazard and should be placed in a passively safe state on a short timescale. For waste containing radioactivity with a relatively short half life, for example Co60 (5.3 years), delaying processing may result in a reduced radiation hazard for the operators managing the waste or a reduction in the volume of wastes. For waste containing radioactivity with a relatively long half-life, for example Cs137 (30.1 years), there is little benefit to be gained from delaying the processing. In the case of plutonium bearing waste, there is an ingrowth of the more radiologically significant Am241, from the decay of Pu241, resulting in a hazard that increases with time. In this case there is a considerable benefit from carrying out the processing without delay.

A4.3.11 Achievement of Passive Safety in Practice

A4.3.11.1 This guidance has described the important features of passive safe storage. A list of general principles is given in Table A4.1. Proposals developed by licensees could meet a majority of these principles but not every one. Licensees should demonstrate and justify that any shortfall against the principles does not result in any significant safety detriment or compromise the overall aim of passive safe storage.

A4.3.11.2 It can be expected that licensees aim to apply the principles for passive safe storage within a framework of reasonable practicability and cost-effectiveness. In the regulatory context, this is interpreted to mean that processing for passive safety should be carried out where it constitutes current best practice and to comply with good engineering principles, unless the costs are grossly disproportionate to the safety benefits.

A4.3.11.3 The application of good engineering principles and modern standards for radioactive waste management, including passive safe storage, is an overarching expectation. As part of their safety case, licensees may employ probabilistic safety assessment methods to demonstrate that the risk from the facilities is acceptable and very low. However, risk assessment results should not be employed to justify not applying sound engineering principles. Inspectors are advised to refer to Appendix 3 for specific guidance in this area.

A4.4 References

1 Review of Radioactive Waste Management Policy – Final Conclusions, UK Government Cm 2919, HMSO 1995.

2 Management of Nuclear Waste. House of Lords Select Committee on Science and Technology, Third Report. March 1999.

3 Internal Hazards. T/AST/014.

4 External Hazards. T/AST/013.

Table A4.1 General Principles for Passive Safety

Principle
The radioactivity should be immobile
The waste form and its container should be physically and chemically stable
Energy should be removed from the waste form
A multibarrier approach should be adopted in ensuring containment
The waste form and its container should be resistant to degradation
Storage environment should optimise waste package life
The need for active safety systems to ensure safety should be minimised
The need for monitoring and maintenance to ensure safety should be minimised
The need for human intervention to ensure safety should be minimised
The storage building should be resistant to foreseeable hazards
Access should be provided for response to incidents
There should be no need for prompt remedial action
The waste packages should be inspectable
The waste packages should be retrievable for inspection or reworking
The lifetime of the storage building should be appropriate for storage period prior to disposal
The storage facility should enable retrieval of wastes for final disposal (or re-storing)
The waste package should be acceptable for final disposal

Appendix 5 Radioactive Waste Minimisation

Contents

A5.1 Introduction

A5.1.1 Radioactive waste is a product of many operations within the nuclear industry. Avoiding the creation of radioactive waste in the first instance and, secondly, minimising the rate at which waste, which must be created, is produced is one of the foremost principles of good radioactive waste management which is embodied in international standards and Government Policy (Ref. 1).

A5.1.2 Number 7 of the principles of radioactive waste management set out by the IAEA (Ref. 2) relates to waste minimisation. It states:

> *The generation of radioactive waste shall be kept to the minimum practicable, in terms of both its activity and volume, by appropriate design measures and operating and decommissioning practices. This includes the selection and control of materials, recycle and reuse of materials, and the implementation of appropriate operating procedures. Emphasis should be placed on the segregation of different types of waste and materials to reduce the volume of radioactive waste and facilitate its management.*

A5.2 Licence Conditions and Safety Assessment Principles

A5.2.1 LC32 requires licensees to make and implement adequate arrangements for minimizing, so far as is reasonably practicable, the rate of production and total quantity of radioactive waste accumulated on a site.

A5.2.2 SAPs P294 and P301 are the key principles for the assessment of radioactive waste minimisation practices. P294 refers to consideration of radioactive waste minimisation during commissioning, operation and decommissioning. P301 addresses the control of discharges of liquid and gaseous wastes, for which authorisation by the environment agencies under RSA93 is required.

A5.2.3 The related SAPs address good radioactive waste management practices whose application will positively affect waste minimisation. Adequate containment, P223, ensures that unnecessary wastes do not arise from the spread of contamination through leakage. Monitoring and characterisation, P298, of waste streams at source allows segregation, P281, and radioactive waste to be directed to the most appropriate management route. Recording quantities and radioactivities of different waste streams, P298, provides the basis for monitoring the effectiveness of radioactive waste minimisation measures. Application of P295 minimises the generation of problematic radioactive waste forms. Provision of appropriate locations for temporary storage of plant items etc., P300, assists in preventing unnecessary disposal of potentially repairable or decontaminable items from maintenance and refurbishment operations.

A5.3 Waste Minimisation Practice

A5.3.1 In general, measures to reduce radioactive waste production at source are more effective than measures taken after the waste has been created. Waste minimisation is fundamental good practice, reduces hazards on site, reduces the potential impact on the environment, and in many cases is cost effective. NII's expectations for the application of waste minimisation includes the following practices (in some cases the practices reduce the accumulation of waste rather than it's creation):

- avoidance of the production of secondary wastes;
- segregation of waste streams (by waste category, physical and chemical properties);
- preventing spread of contamination;
- recycling and reusing material;
- waste clearance;
- decontamination;
- volume reduction; and
- disposal.

A5.3.2 In many cases, there are alternative techniques for waste minimisation. The licensee should demonstrate that the chosen technique, or combination of techniques, represent the Best Practical Environmental Option (BPEO). The demonstration of the BPEO is particularly relevant to identified disposal routes as regulated by the environment agencies, including routine discharges.

A5.3.3 NII expects the safety cases for all nuclear facilities to include a demonstration that the rate of production and accumulation of waste has been reduced so far as is reasonably practicable. This should include an optimisation study of the activity in liquid and gaseous routine discharges, solid waste arisings, occupational exposure and environmental impact. The licensee must be able to demonstrate a structured, site wide (and licensee wide, where appropriate) approach which should take into account best nuclear industry practice. The effectiveness of the approach should be measurable.

A5.3.4 Consideration during Design

A5.3.4.1 Waste minimisation should be considered at the design stage of a new plant, and when modifications are made to existing plant. The implications for waste generation should be taken into account in:

- process selection;
- plant layout;
- choice of components and materials; and
- decontaminable construction materials.

A5.3.4.2 Similarly, good operating practices should be defined at the outset to limit the generation of secondary wastes (for example, use of reusable protective clothing and suitable packaging materials).

A5.3.5 Initiatives during Operation

A5.3.5.1 At an operating plant, there remains considerable potential for significant reductions in radioactive waste generation through the application of good waste minimisation practices. It is acknowledged that significant design changes to operating facilities to minimise radioactive waste arisings are not usually a cost effective option. Nevertheless, the licensee's reviews of operational processes and implementation of improvements can lead to waste minimisation benefits.

A5.3.5.2 Waste minimisation can be achieved through a process of continuous improvement initiated by a commitment from senior management as part of the declared licensee's policy on radioactive waste management. The continuous improvement programme needs to commit adequate resources to waste minimisation, for example, setting up of dedicated trained team with the objectives of identifying and ranking waste generation practices in the licensee's operations and reviewing and feeding back observations and recommendations into operational procedures.

A5.3.5.3 Waste minimisation forms part of the objectives of an environmental management system and accreditation to ISO 14001 (Ref. 3) may be used as an indication of the licensee's commitment to waste minimisation.

A5.4 References

1 Review of Radioactive Waste Management Policy – Final Conclusions, UK Government Cm 2919, HMSO 1995.

2 IAEA Safety Fundamentals, Safety Series No.111-F, The Principles of Radioactive Waste Management, Vienna, 1995.

3 BS EN ISO 14001: Environmental Management Systems. Specification with Guidance for Use. 1996

Appendix 6 Inspection of Accumulated and Stored Radioactive Materials and Radioactive Waste

Contents

A6.1 Introduction

A6.1.1 Radioactive materials and radioactive waste are accumulated during the operating and decommissioning phases in the lifecyle of a nuclear facility. For those radioactive wastes for which there is no current disposal route, licensees will need to plan for long periods of storage. As explained in section 6.10, for radioactive waste and material being placed in storage now, an overall period of containment of at least 150 years should be assumed. The licensee will need to periodically inspect the radioactive waste, and associated accumulation and storage arrangements, in order to confirm that the condition of the waste packages and facilities is acceptable for future safe management. Confirmatory checks may be made by NII if it is considered necessary.

A6.1.2 With respect to NII's responsibility to administer NIA65, and to review nuclear and radiological safety issues at nuclear sites, the term inspection is used to cover a much wider range of activities than is addressed by this Appendix. All licence conditions apply to the process of managing radioactive materials and radioactive waste and inspection could cover any of them. The scope of this Appendix is limited to the inspection of radioactive materials and radioactive waste, waste packages and facilities.

A6.2 Licence Conditions and Safety Assessment Principles

A6.2.1 LC28 and 29 are particularly relevant to the inspection of radioactive waste and radioactive materials and the associated storage arrangements. These LCs require the licensee to make and implement arrangements for regular and systematic examination, inspection, maintenance and testing. Related LCs are LC25, which requires that adequate records of inspections are made (see Appendix 7), and LC34, which requires radioactive waste and radioactive material to be adequately controlled and contained.

A6.2.2 SAPs P97 - 101 cover maintenance, inspection and testing of nuclear facilities and include the expectation that the layout of plant will facilitate inspection and that licensees will carry out inspections as appropriate throughout plant life. P296 and P298 cover the expectation that the licensee will monitor radioactive waste stored on site to ensure that it remains in a safe state, in a form which minimises the hazard of storage, is compatible with retrieval, subsequent storage, transport and disposal routes.

A6.3 Requirements for Inspection

A6.3.1 The fundamental objective of inspecting accumulated and stored waste is to confirm that the waste packages and facilities are, and will remain, in an acceptable condition for continuing safe storage, retrieval, conditioning and final disposal.

A6.3.2 In defining their inspection regimes, licensees should develop acceptance criteria against which the condition of the waste is to be assessed. They should justify the method of inspection (which could involve visual, non-destructive or destructive techniques) and the frequency of inspections. Where the inspection regimes are based on predicted rates of degradation, inspections should also be undertaken at appropriate time intervals to confirm that the waste is not deteriorating to an unexpected degree.

A6.3.3 Inspection of Accumulations of Raw Radioactive Waste

A6.3.3.1 At nuclear facilities some radioactive wastes are accumulated in their raw form, with the intention of retrieving them for treatment and packaging, either after the plant has shutdown, or when sufficient waste has been accumulated to make a campaign cost-effective. Typical examples of such waste forms include spent ion-exchange resins and sludges which are accumulated in tanks, awaiting retrieval and encapsulation in cement in steel drums.

A6.3.3.2 There are a number of processes that can change the physical and chemical form of the raw radioactive waste during accumulation. For example, the agglomeration and consolidation of ion-exchange resins and sludges stored under water in tanks can adversely affect the ability to retrieve them by hydraulic means. Similarly, the corrosion of metallic solid radioactive wastes can adversely affect their retrieval by mechanical means. An important aim of inspections is to confirm that the rate of degradation of the waste will not impact on the ability to retrieve and process the waste in the future as planned. This will normally be achieved through direct sampling and analysis of the accumulated waste to verify its condition.

A6.3.4 Inspection during Passive Safe Storage of Radioactive Waste

A6.3.4.1 Radioactive wastes for which there is no current disposal route should be processed for long term passive safe storage. Although one of the aims of passive safety is to minimise the need for surveillance and inspection to ensure safety, it is expected that periodic inspections will be carried out to confirm that the condition of the waste and its storage are not deteriorating adversely, and to confirm its continuing acceptability for safe storage, and ultimately retrieval, transport and disposal. Inspection will not be restricted to the waste packages but will cover the storage facilities and buildings, and the associated safety arrangements.

A6.3.4.2 NII expects the design of storage facilities to take account of the needs for inspection, retrieval and transfer. In general, NII expects all the radioactive waste accumulated or in storage to be routinely inspectable. Where only a fraction of the waste is to be inspected, the licensee should justify that the sample is representative. Facilities should include provision for inspection of all the packages and the ability to retrieve any package, for detailed inspection, within a reasonable period of time, certainly no longer than a week. Suitable areas should be provided for detailed inspection or for carrying out remedial treatment of packages. There may be benefit to be gained from including the facility for members of the public to view the waste for reassurance purposes.

Appendix 7 Records for Radioactive Waste Management and Decommissioning

Contents

A7.1 Introduction

A7.1.1 This Appendix provides guidance on the maintenance of records for the management of radioactive materials and radioactive waste as well as for decommissioning. Specific guidance on record storage is given in an Assessment Guide (Ref. 1).

A7.1.2 Government Policy (Ref. 2) with respect to radioactive waste management and decommissioning makes no specific reference to records. However, the concept of sustainable development is described as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Where radioactive waste management and decommissioning strategies last for significant periods of time, then responsibilities will be passed to future generations. In order to comply with the concept of sustainable development, it will be necessary to provide the future generations with all the information they need to manage the nuclear facilities safely. This can be achieved by making adequate records of the nuclear facilities, and maintaining them so that they can be accessed in the future.

A7.2 Licence Conditions and Safety Assessment Principles

A7.2.1 LC6 requires licensees to make adequate records to demonstrate compliance with each condition of the site licence, and to ensure that such records are preserved for a further 30 years, or for any other period that NII may approve. LC25 requires licensees to ensure that adequate records are made and kept of the operation, inspection and maintenance of nuclear facilities. This includes the amount and location of all radioactive waste and radioactive material stored or accumulated on the site.

A7.2.2 SAPs P298 and P308 describes the expectation that licensees should make adequate provision for recording appropriate details of radioactive waste and scrap in a manner which is durable for the anticipated period prior to final disposal. More generally, relating to the nuclear facilities as a whole, P320 expects licensees to make provision for updating and preserving documents relevant to plant safety. Particular attention should be paid to those records which would assist management in the event of incidents, in making modifications and in decommissioning.

A7.2.3 The record preservation period of 30 years, as required by LC6, reflects the requirements of NIA65 with respect to third party liability. This period starts from the time when decommissioning and decontamination of the plant is complete and all radioactive waste has been transferred to another location or disposed of.

A7.2.4 However, it is clear that the records required to support the safe management of radioactive wastes and radioactive materials during long term storage and final disposal will need to be accumulated and retained over very long periods of time. Similarly, records will be required to support the safe implementation of decommissioning. As a result, consideration needs to be given to the content of such records and the form in which they are kept. Records should be held by the licensee until the responsibility for the wastes and materials has been passed to another body such as the operator of a disposal facility.

A7.3 Guidance on Records

A7.3.1 NII expectations with respect to the preservation of licensee's records can be summarised as:

- Records should contain all the information that may be required in the future.
- Records should be accessible to those who will consult them.
- Records should be assembled and maintained in a secure form.

A7.3.2 <u>Purpose of Records</u>

A7.3.2.1 As noted in section A7.2.3, the information contained in records is required for principally two reasons. Firstly, in connection with nuclear liabilities and, secondly to support future safety.

A7.3.2.2 Nuclear liabilities are not relevant to this guidance but it is noted that the liability of licensees for harm to any person, damage to property and the consequences of nuclear incidents has been established under the Paris Convention 1960 and the Brussels Convention 1963. The content and availability of operational records will clearly be essential in any future legal proceedings.

A7.3.2.3 Of relevance to this guidance, is the role that operational records play in supporting future activities in radioactive waste management and decommissioning. Such activities may include:

- reviews of strategic planning and safety cases;
- ensuring continuing safe storage;
- retrieval of waste;
- repackaging of waste;
- disposal of waste;
- dismantling structures and plant;
- management following incidents;
- making modifications;
- ongoing financial provision; and
- training of staff.

A7.3.2.4 In addition to the regulators and the licensee, records may be of value to other organisations or persons in the future, such as:

- any successor licensee;
- the operator of a disposal facility;
- members of the public;
- the European Commission; and
- international organisations (for example, OECD/NEA, IAEA).

A7.3.3 Content of Records

A7.3.3.1 It is beyond the scope of this guidance to define the extent of the records that licensees are expected to assemble with respect to their nuclear facilities, but the following list provides some guidance specifically for radioactive materials and radioactive waste:

- characteristics of the radioactive waste and radioactive materials including the radionuclide inventory, the amount, radiological classification, physical and chemical form;
- the origin and location on site;
- development and specification of conditioning recipes;
- development and specification of packages;
- details of packaging;
- plant, stores, buildings and structures;
- design and construction, materials;
- inspection, maintenance and test results;
- records of all waste disposals;
- quality records;
- safety case records:
    - previous versions,
    - references,
    - supporting documentation, references and data,
    - modifications,
    - periodic safety reviews,
    - quinquennial reviews of decommissioning.
- record of incidents;
- research and development; and
- regulatory interaction:
    - correspondence,
    - concerns and responses,
    - consents, approvals and directions etc,
    - letters of comfort.

(The list is not intended to be comprehensive.)

A7.3.4 Storage Period and Method

A7.3.4.1 The fundamental requirement is that records should be maintained in a secure and accessible form for as long as the information could be of value in the future. Because of the need for long term storage prior to disposal, and also because some licensees have proposed decommissioning programmes involving significant deferral times, the projected storage period for many records associated with radioactive waste management and decommissioning will be greater than 100 years. The means of preservation of the records during this time and the retrieval of the information also needs to be considered and should taken account of legal requirements (i.e. suitability for use in legal proceedings), ageing, fire, flood and potential obsolescence of the retrieval system.

A7.3.4.2 There is no single recommended storage medium for archives. The Public Records Office, for example, keeps records on a variety of media including paper, electronic data, microfilm, microfiche etc. The most pertinent British Standard is BS5454 (Ref. 3), and two others of relevance are BS1153 (Ref. 4) and BS5699 (Ref. 5). The licensee should demonstrate the adequacy of its chosen storage medium/media, including redundancy or duplicate records, and should describe how it will review those arrangements in the future. Specific guidance on record storage is available (Ref. 1).

A7.3.5 BRIMS

A7.3.5.1 UK Nirex has been working with the nuclear industry, NII, other Government departments and the environment agencies, to develop a database entitled the British Radwaste Information Management System (BRIMS). The primary objective of the system is to provide a UK information system that will provides a means of accumulating and storing the data required for the future safe management of radioactive material and radioactive waste, pending final disposal. Data from the system can be used to support a variety of activities such as the preparation of the UK Radioactive Waste Inventory (Ref. 6), strategic reviews, safety case development, Best Practical Means (BPM) and Best Practical Environmental Option (BPEO) studies, waste movement tracking etc.

A7.3.5.2 Information is recorded within three related modules in the database. The Inventory Module deals with the characteristics of the radioactive waste itself, the Waste Management Module deals with the buildings and facilities used to store the waste, and the Packages Module deals with the packages in which waste is transferred and may ultimately be disposed. An overview of BRIMS is given in Ref. 7 and a detailed description of the data which can be recorded within BRIMS is given in Refs. 8 and 9.

A7.4 References

1 Record Storage. T/AST/033.

2 Review of Radioactive Waste Management Policy – Final Conclusions, UK Government Cm 2919, HMSO 1995.

3 BS5454, Recommendations for the Storage and Exhibition of Archival Documents.

4 BS1153, Process and Storage of Silver-Geletin Type Material.

5 BS5699, Process Photographic Film for Archival Records.

6 The 1998 UK Radioactive Waste Inventory, DETR and Nirex 1999.

7 British Radwaste Information Management System (BRIMS), AG Davies et al., pp315 - 318, Proc. Sixth International Symposium of the Society for Radiological Protection, Southport June 1999.

8 BRIMS 1 User's Guide, VECTRA Technologies Ltd., Rev 0, May 1999.

9 Data Definition Specification for the British Radwaste Information Management System, EASAMS, February 1999.

Appendix 8 Management of Radioactively Contaminated Land

Contents

A8.1 Introduction

A8.1.1 There are a significant number of instances of radioactively contaminated ground on nuclear licensed sites. This contamination is the result of historical incidents involving spillage or leakage, or the placement of radioactive material in the ground. Inspectors should note that, historically, licensees have not always actively managed contaminated ground on their sites. In very recent years, the profile of contaminated ground has been raised as licensees have appreciated that it represents a substantial liability. As a result, licensees are putting in place measures to manage the contaminated ground.

A8.1.2 It is NII's view that, unless it is an authorised disposal, radioactively contaminated ground, or emplaced radioactive material, on a nuclear licensed site represents an accumulation of radioactive waste. It should be managed as such by the licensee who is responsible for managing all the radioactive material on the site and for demonstrating that it is being appropriately dealt with.

A8.1.3 The existence of radioactively contaminated ground will be an issue for licensees seeking to complete the delicensing of their nuclear sites. Further guidance on delicensing and the development of appropriate criteria is given in Appendix 1 of Ref. 1.

A8.1.4 The Government intends to introduce regulations for the control of radioactively contaminated land, other than on nuclear sites, that are consistent with the contaminated ground provisions of the Environment Bill and a consultation process is underway (DETR, Ref. 2). The outcome of this process will inform NII's regulation of the control of contaminated ground on nuclear sites. Further background information is available from EA in Ref. 3 and from the Safegrounds project (Ref. 4).

A8.2 Licence Conditions and Safety Assessment Principles

A8.2.1 NII expects licensees to demonstrate that they are managing radioactively contaminated ground in compliance with the requirements of all the LCs. Particularly relevant are LC4, LC14, LC23, LC25, LC32 and LC34. These licence conditions require licensees to control or contain nuclear matter, including radioactive materials and radioactive waste, to record the amount of radioactive material and its location, and to justify and demonstrate the adequacy of the arrangements to maintain safety by means of a safety case.

A8.2.2 The radiological protection of workers and the public is covered by the Ionising Radiations Regulations 1999 [IRR99] which imposes obligations in respect of containment, assessment, contingency plans and reporting of leakages (Regulations 29(1), 7, 12(1) and 30(1)).

A8.2.3 Although the SAPs do not refer specifically to contaminated ground, the principles that address the management of radioactive materials and radioactive waste are all applicable. In addition, SAP59, one of the principles applying to the selection of a nuclear site, expects a licensee to determine the dispersion of radioactive releases from a site, including migration via ground water flow, using established and well researched models. NII therefore expects the licensee to quantify the environmental impact of contamination as a part of its strategy for management and remediation.

A8.3 Guidance on the Management of Radioactively Contaminated Land

A8.3.1 <u>Strategy and Safety Case</u>

A8.3.1.1 Having established that contaminated ground on a nuclear licensed site represents an accumulation of radioactive waste, it follows that the licensee should manage the contaminated ground in accordance with the conditions of the site licence and Government Policy.

A8.3.1.2 The licensee should develop and maintain a preferred strategy for the management of the contaminated ground. The strategy should cover the same range of issues that are considered for any radioactive material or radioactive waste on the site. The strategy should be developed on a case by case basis, and the approach will depend on the particular circumstances of each instance of contamination. The strategy should be part of the overall strategy for the site and integrated with the decommissioning strategy.

A8.3.1.3 The strategy should describe the extent and nature of the contaminated ground and the options for managing it. The preferred option and timescale should be justified in terms of the factors that have been taken into account. It should cover the means by which the radioactive waste will be managed in the short term, which may involve remediation work, and the plan for final disposal. Alternative options should be identified in case the preferred option has to be changed as a result of unforeseen circumstances. The management and remediation will need to be costed to the extent that judgments can be made on the practicality, and so that the adequacy of financial provisions can be demonstrated.

A8.3.1.4 The management of contaminated land should aim to achieve, so far as is reasonably practicable, the following:

i) to minimise the migration of radioactive contamination on-site and, in particular, to prevent its spread off-site;
ii) to retrieve contaminated material for storage pending a disposal route becoming available; or
iii) if the selected option (BPEO/ALARP) is to leave the contamination in place then to implement measures to achieve in-situ stabilisation.

A8.3.1.5 Licensees should develop and maintain a safety case for the management of the contaminated ground. The content of a safety case should be similar to that for other accumulations of radioactive material or radioactive waste. This guidance does not aim to be prescriptive, however, the following information can be expected to form part of a safety case for contaminated ground: description of material (radioactive inventory, physical and chemical form, origin); place (location, geological conditions, hydrological conditions, mobility); modern standards and good engineering practice; safety criteria; safety management system (policy, strategy, organisation, responsibilities, procedures); method of control (natural barriers, artificial barriers, intervention means, retrieval, monitoring); assessment of risk (routes for exposure of public and workers, risk to public, risk to workers); uncertainties (identification and quantification of uncertainties) and a demonstration of ALARP.

A8.3.1.6 On large licensed nuclear sites, it is the practice for individual post holders to be invested with the responsibility for only part of the site or for specific buildings. Contaminated ground may extend under and around buildings and across the boundaries of responsibility on a site. To avoid potential ambiguity of responsibility, licensees should clearly define the responsibilities associated with instances of contaminated ground, and ensure that the control is coordinated for the whole site.

A8.3.2 Prevention of Leakage

A8.3.2.1 The first priority is to prevent ground contamination occurring. Good engineering practice with respect to the control of mobile liquid radioactive waste includes processing for passive safety, the provision and maintenance of adequate containment, prevention of inadvertent discharge, leak detection, double containment, bunding and contingency arrangements. Where a leak of radioactivity to the ground has been identified, the initial priority is to establish the source and then to take measures to terminate or minimise the leakage, and to recover the radioactive contamination. Subsequently, it will be appropriate to review existing arrangements to determine whether they are acceptable or whether actions are required to reduce the possibility of future leakage.

A8.3.3 Radiological Concerns of Contaminated Ground

A8.3.3.1 The safety concern from contaminated ground is the risk that uncontained radioactivity will lead to the radiation exposure of workers and, through environmental pathways, exposure of members of the public. The assessment of the radiological impact of contaminated land should consider the source term, the exposure pathways and the receptor.

A8.3.3.2 The potential pathways for the exposure of workers on a site are personal contamination, exposure to airborne activity and direct radiation. Workers undertaking intervention tasks associated with remediation of contaminated ground will be subject to additional risk of exposure. Finally, there is a risk of accidental exposure to workers as a result of site activities that disturb contaminated ground.

A8.3.3.3 The main pathways for the exposure of the public are those associated with airborne radioactivity which may result from the suspension of surface contamination, and those associated with water borne radioactivity leaking beyond the site boundary and possibly into public water supplies. Birds and animals may also spread contamination if it is not properly controlled. Exposure of the public to direct radiation from ground contamination on a nuclear site is very unlikely ever to be significant. However, this is likely to be an issue in terms of how the public perceives the degree of control exercised by the licensee and regulators.

A8.3.3.4 One of the significant environmental concerns is the potential contamination of groundwater. The major use of groundwater is for public and private water supply, and it is a valuable resource. If groundwater becomes contaminated it is very difficult to rehabilitate since the low rates of flow mean that self purification is likely to be measured in decades. Hence the major emphasis relates to the prevention of pollution. Details of groundwater protection policies of the Environment Agency and the CEC are presented in Refs. 5 and 6.

A8.3.4 <u>Characterisation of the Contamination</u>

A8.3.4.1 Licensees should characterise contaminated ground in terms of the location, the radionuclide inventory and concentration distribution in the ground, and the degree to which the contamination is spreading or has the potential to migrate.

A8.3.4.2 If the source and magnitude of the leak that caused the radioactive contamination is known, then that information can be used to provide an estimate of the radionuclide content and total inventory of the contamination. This can be supplemented by radiochemical analysis of samples taken from the contaminated ground. The radioactivity in contaminated ground should be included in future issues of the National Inventory. Inspectors may note that estimates of radioactivity in major instances of contaminated ground at Sellafield have been included in the UK National Radioactive Waste Inventory (Ref. 7).

A8.3.4.3 The extent of contaminated ground can be determined by the radiochemical analysis of core samples taken from appropriate locations. Core samples also provide information on the biochemical and physical conditions in the ground. Data can be presented in the form of 3-dimensional contamination contours. Radiochemical analysis of groundwater samples, taken from appropriate locations, can provide information on the rate of migration of radioactivity from the contaminated region and on the aquifer chemistry. Licensees should describe and justify their monitoring practice.

A8.3.4.4 Inspectors are referred to Refs. 8, 9 and 10 as examples of international experience of the characterisation of contaminated ground. For a lead into obtaining technical advice on the techniques for groundwater investigation, including sampling devices, siting of bore holes, groundwater pollution prevention and remediation, Inspectors are referred to Ref. 11.

A8.3.5 <u>Hydrogeological Characterisation</u>

A8.3.5.1 Licensees will need to demonstrate a thorough understanding of the subsurface, as this is an essential element for the planning of the containment and remediation of contaminated ground. Hydrogeological properties such as permeability, porosity and hydraulic gradients control the flow and transport of contamination in groundwater, which can be envisaged as underground plumes. Other properties, such as variations in the geological structure, can lead to paths of enhanced flow. In some cases the plumes may travel beyond the site fence. In addition, the plumes may eventually intercept with other flows and could enter water courses that are the source of public water supplies.

A8.3.5.2 Licensees should allow for potential changes to the hydrogeology when undertaking major building or demolition projects on a nuclear site. For example, when buildings or paved areas are removed, groundwater levels may rise. In addition, bore holes introduced for site investigations and characterisation work, can introduce low resistance pathways between different aquifers.

A8.3.6 Remediation Technology

A8.3.6.1 Licensees should demonstrate a thorough understanding of the physical and chemical nature of the contamination as this is essential to the assessment of the impact and the selection of an appropriate remediation scheme. Contamination, such as tritium, which is soluble and not readily adsorbed by soil, may migrate rapidly to and within groundwater. Contamination which is more readily adsorbed will not tend to spread as quickly.

A8.3.6.2 Ground contamination and its remediation is an issue of international concern. Inspectors are referred to recent conference proceedings, Refs. 8 and 9, for examples of information on remediation technology. Ref. 12 gives an overview of the technology research and development activities that the US DOE is currently engaged in for the remediation of contaminated soil and groundwater. Ref. 11 gives a UK overview for the remediation of non-radioactive contamination, many of the techniques are equally applicable to radioactive contamination.

A8.3.6.3 The range of potential remediation concepts is outlined below, as guidance to Inspectors:

- Methods for the remediation of buried material or radioactive waste that is a source of subsurface contamination, for example:
    - retrieval of the contaminated material and soil for treatment with subsequent back fill or off-site disposal; and
    - in-situ stabilisation.
- The migration of subsurface contamination can be restricted by containment using, for example:
    - surface caps or covers;
    - impermeable vertical barriers;
    - permeable vertical barriers; and
    - hydraulic controls.

- Contamination in soil and groundwater can be treated using techniques such as:

    - pump-and-treat;
    - in situ filters; and
    - in situ immobilisation.

- There are a number of techniques developed for retarding the contamination in a surface spill from migrating into the ground and groundwater, and also from the risk of becoming suspended in the atmosphere. These include freezing, injection of gel and the application of impermeable surface coatings.

A8.4 References

1 Decommissioning on Nuclear Licensed Sites Sites, T/AST/026.

2 Control and Remediation of Radioactively Contaminated Land: a Consultation Paper. Department of the Environment Transport and the Regions, The Scottish Office, The Welsh Office. February 1998.

3 Technical Support Materials for the Regulation of Radioactively Contaminated Land. R&D Technical Report P307. Environment Agency, 1999.

4 The Safegrounds Project. (www.safegrounds.com)

5 Groundwater Protection Policy, NRA, Bristol 1992.

6 Council of the European Communities, Resolution of 25th February 1992 on the Future of Community Groundwater Policy, Official Journal ((2/C/59/02), March 1992.

7 The 1998 UK Radioactive Waste Inventory 1998, DETR and Nirex 1999.

8 International Topical Meeting on Nuclear and Hazardous Waste Management, Proceedings of Conference, Seattle, August 18 –23, 1996.

9 International Conference on Nuclear Waste Management and Environmental Remediation, Proceedings of Conference, Prague, September 5 – 11, 1993.

10 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Nureg-1575, EPA402-R-97-016, December 1997.

11 Groundwater – Pollution Prevention and Remediation, Course organised by IBC, Manchester, January 22 – 24, 1996.

12 Subsurface Contaminant Focus Area – An Overview, Skip Chamberlain et al, pp1406-1413, from Ref. 9.