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UK ABWR

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UK ABWR Generic Design Assessment

Radioactive Waste Management Arrangements

Hitachi-GE Nuclear Energy, Ltd.

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1. Acronyms and Abbreviations

ABWR	Advanced Boiling Water Reactor
ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
BAC	Bead Activated Carbon
BAT	Best Available Technique
BSC	Basis of Safety Case
Bq (kBq, MBq, GBq)	Becquerel (Kilo Bq, Mega Bq, Giga Bq)
BWR	Boiling Water Reactor
CAD	Controlled Area Drain
CCTV	Closed Circuit Television
CD	Condensate Demineraliser System
CF	Condensate Filter System
CONW	Concentrated Waste
CST	Condensate Storage Tank
CUW	Reactor Water Clean-up System
DCIC	Ductile Cast Iron Container
DEFRA	Department for Environment, Food and Rural Affairs
DSP	Dryer Separator Pool
DWMF	Decommissioning Waste Management Facility
EPR2016	The Environmental Permitting (England and Wales) Regulations 2016
EP-RSR	Environmental Permit - Radioactive Substances Regulation
EU	European Union
F/D	Filter-Demineraliser
FPC	Fuel Pool Cooling and Clean-up System
GAC	Granular Activated Carbon
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
GEP	Generic Environmental Permit
GWd/tU	GigaWatt-Days / Metric Ton of Uranium
HAW	Higher Activity Waste

HCW	High Chemical Impurities Waste System
HEPA	High Efficiency Particulate Air
HF	Human Factors
HFI	Human Factors Integration
HHISO	Half Height ISO container
Hitachi-GE	Hitachi-GE Nuclear Energy, Ltd.
HLW	High Level Waste
HOP	Hydrazine, Oxalic acid and Potassium permanganate
HSE	Health and Safety Executive
HVAC	Heating Ventilating and Air Conditioning
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
ILWS	ILW Store
ISO	International Organisation for Standardisation
IRR99	The Ionising Radiations Regulations 1999
IWS	Integrated Waste Strategy
LAW	Lower Activity Waste
LC	Licence Condition
LCW	Low Chemical Impurities Waste System
LD	Laundry Drain System
LLW	Low Level Waste
LLWR	Low Level Waste Repository site
LoC	Letter of Compliance
LPRM	Local Power Range Monitor
LWMS	Liquid Waste Management System
MILWSP	Modular Intermediate Level Waste Solidification Plant
MMA	Monitoring and Marshalling Area
MPC	Multipurpose Container
MVDS	Modular Vault Dry Store
MWt	Mega Watt thermal
NDA	Nuclear Decommissioning Authority
NFWC	Non-Fuel Waste Container
NPP	Nuclear Power Plant

NSU	Neutron Source Unit
OECD	Organisation for Economic Co-operation and Development
OG	Off-Gas system
ONR	Office for Nuclear Regulation
OSPAR	Oslo and Paris Convention on Protection of the Marine Environment of the North East Atlantic
P&ID	Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs
PCI	Pellet-Cladding Interaction
PCSR	Pre-Construction Safety Report
PHM	Package Handling Machine
PIC	Package Inspection Cell
PIR	Package Identification Room
PRB	Package Receipt Bay
POCO	Post Operational Clean Out
PPE	Personal Protective Equipment
PWR	Pressurised Water Reactor
QA	Quality Assurance
R/B	Reactor Building
RCA	Radiation Controlled Area
RD	Radioactive Drain transfer system
REP	Radioactive Substances Regulation – Environmental Principle
RHR	Residual Heat Removal system
RIN	Reactor Internals
RO	Regulatory Observation
RPV	Reactor Pressure Vessel
RQ	Regulatory Query
RSW	Reactor Shield Wall
Rw/B	Radwaste Building
RWMA	Radioactive Waste Management Arrangements
RWM	Radioactive Waste Management Limited, a wholly-owned subsidiary of the NDA.
RWMC	Radioactive Waste Management Case
SAP	Safety Assessment Principles

S/B	Service Building
SCV	Secondary Containment Vessel
SF	Spent Fuel
SFIS	Spent Fuel Interim Store
SFP	Spent Fuel storage Pool
SILW	Solid ILW treatment facility
SJAE	Steam Jet Air Ejector
SLLW	Solid Low Level Waste
SPCU	Suppression Pool Clean-Up system
SQEP	Suitably Qualified and Experienced Person
SRNM	Start-up Range Neutron Monitor
SS	Spent Sludge System
SWF	Solid Waste Facility
T/B	Turbine Building
THISO	Third Height ISO container
TIP	Traversing In-core Probe
UK	United Kingdom
UHP	Ultra High Pressure
VLLW	Very Low Level Waste
WAC	Waste Acceptance Criteria
WAMH	Waste Addition and Mixing Head
WILW	Wet-solid ILW Processing System
WLLW	Wet-solid LLW Processing System
WSC	Waste Services Contract

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3. Introduction

This Radioactive Waste Management Arrangements (RWMA) document fulfils the requirements of the Environment Agency Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs (P&ID) [Ref-1] for the management of wastes and spent fuel (SF) from the Hitachi-GE United Kingdom Advanced Boiling Water Reactor (UK ABWR). It also considers the relevant Environment Agency Radioactive Substances Regulation Environmental Principles (REP) [Ref-2] and the applicable requirements of the Office for Nuclear Regulation (ONR) [Ref-3].

This RWMA document has been produced to support the GDA Integrated Waste Strategy (IWS) [Ref-4], and has been developed with potential site operators in mind, to ensure that any site specific IWS can follow on from this generic strategy without major changes to the fundamental approach outlined in this document. This document also provides a detailed reference to support the Radioactive Waste Management Case (RWMC) [Ref-5].

The Radioactive Waste Management Arrangements cover the UK ABWR lifecycle (including decommissioning), spanning the arising, management and disposal of the wastes. The strategies outlined in this document cover the management of the following waste types and Spent Fuel (SF):

- Aqueous liquid radioactive waste (Section 8)
- Gaseous radioactive waste (Section 9)
- Solid radioactive waste (Section 10)
- Non-aqueous liquid radioactive waste (Section 10.6)
- Spent Fuel (SF) (Section 10.5)

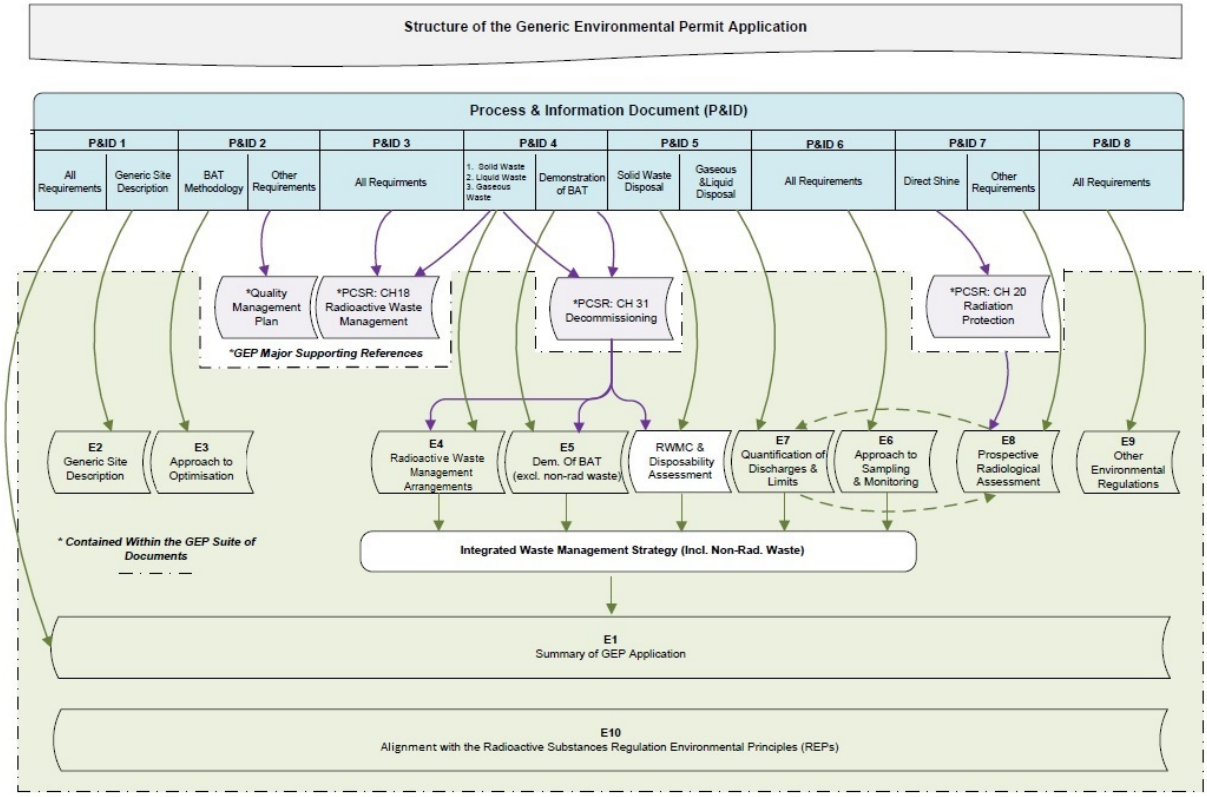
The nature of non-aqueous liquid waste, for example oil, prohibits its release directly to the environment, even after treatment, and therefore the strategy for its management, treatment and disposal are similar to those for solid waste, hence its presentation alongside the solid radioactive waste strategy.

The engineered systems for the management and treatment of liquid, gaseous and solid radioactive waste streams are described in detail in Chapters 16 and 18 of the Pre-Construction Safety Report (PCSR), notably:

- Chapter 16: Auxiliary Systems [Ref-6], section:
    - 16.5 – Heating Ventilation and Air Conditioning System
- Chapter 18: Radioactive Waste Management [Ref-7], sections:
    - 18.5 - Liquid Waste Processing in the Radwaste Building
    - 18.6 - Wet-solid Waste Processing in the Radwaste Building
    - 18.7 - Off-Gas System
    - 18.8 - Heating Ventilation and Air Conditioning System
    - 18.9 - Tank Vent Treatment System
    - 18.10 - High Level Waste Processing
    - 18.11 – Intermediate Level Waste Store
    - 18.12 – Low Level Waste Processing

The designs of the solid, liquid and gaseous systems are underpinned by the Demonstration of BAT (Best Available Techniques) report [Ref-8].

The overall structure of the Generic Environmental Permit (GEP) submission and the relationship between all the documents is shown in the GEP Summary document [Ref-9] and reproduced here in Figure 3-1.



E1-9 Core GEP documents
PCSR Pre-Construction Safety Report

Figure 3-1: Structure of the GEP Application

The radioactive waste strategies presented in this management arrangements document have been developed by Hitachi-GE for the UK ABWR with the UK regulatory system in mind. Where applicable, the current Japanese practice for dealing with a specific waste stream is outlined and discussed in the context of current UK practices. Where UK practice differs this is noted and management options discussed for the specific waste stream. In such circumstances a recommendation for additional work is included to develop appropriate solutions, which at this stage comprise a number of suitable options with the identified preferred options selected for GDA.

4. Waste Management Objectives and Principles

The design of the UK ABWR has been developed with due consideration of the requirement to minimise its environmental impact. Following the principle of continuous improvement, Hitachi-GE policy is to aim for ongoing improvement of the UK ABWR's environmental performance with respect to other operational reactor designs as well as previous operational ABWR nuclear power plants (NPPs). The high level objectives and principles used within Hitachi-GE to inform decision making and design development for systems having a bearing on the generation or treatment of radioactive wastes are described in this chapter. These have been developed within Hitachi-GE with future site operators in mind: the waste management objectives and principles are used to guide the development of strategies and their implementation. They take due consideration of the objectives and principles (REPs) published by the Environment Agency [Ref-2] and the ONR Safety Assessment Principles (SAPs) [Ref-3] and consistently look to apply the waste management hierarchy and proximity principle.

4.1 Objectives

Hitachi-GE's objectives for its UK ABWR Radioactive Waste Management strategy are to:

- Safely control and account for radioactive waste.
- Protect human health and the environment both now and in the future. Where it is reasonably practicable, deliver this objective by minimising waste production, concentrating, containing and packaging the waste and isolating it from the accessible environment by disposing of it in appropriate geological facilities at the earliest opportunity.
- Balance the use of environmental, social and economic resources in an optimal way.
- Ensure undisturbed power production from the reactor, provided health, safety and environmental protection are not compromised.

4.2 Principles

The principles held by Hitachi-GE to be applied when developing and implementing waste management and decommissioning strategies for the UK ABWR are presented in Table 4.2-1 below. The regulatory reference is given against each principle along with an example of where the principle has been considered in this strategy.

Table 4.2-1: Hitachi-GE Waste Management Principles

Hitachi-GE Waste Management Principles	References	Considered in this document
A Waste Management Strategy should be produced taking account of the Waste Hierarchy.	REP - RSMDP1 SAP - RW.1 SAP - ENM.1	This strategy document, underpinned by the references herein.
Hitachi-GE will ensure those responsible for design and implementation of radioactive waste management systems are Suitably Qualified and Experienced Person (SQEP) for their roles.	SAP - MS.2	Section 11 identifies the requirement for SQEP.
Design and design acceptance processes will include taking advice from suitable Radioactive Waste Advisers and Radiation Protection Advisers.	IRR99 EPR2016	Section 7.2 states that Radiological Protection Advisors and Radioactive Waste Advisers are integral to the waste management design process.
BAT to minimise the generation of radioactive waste should be applied during design, commissioning, operation and decommissioning of the plant.	REP - RSMDP3, 5 SAP - RW.2	BAT description and references are presented in section 7. BAT is discussed and demonstrated throughout the document.

Hitachi-GE Waste Management Principles	References	Considered in this document
All liquid and gaseous discharges shall be made via abatement plant that represents BAT.	REP- RSMDP15	The liquid and gaseous management systems are presented with reference to BAT in Sections 8 and 9. The non-aqueous liquid waste strategy is given in Section 10.6 The waste treatment facility example design overviews in Section 11 identify gaseous and liquid management systems.
BAT should be used to minimise the radiological impact to the public and the environment in the design and operation of liquid and gaseous waste discharge systems.	REP - RSMDP7 REP – CLDP1 SAP - ECV.2	
BAT should be used in the design decision making in selecting the best practicable option for disposal of each solid waste stream, and minimising the volume of packaged waste for disposal.	REP - RSMDP4 REP - RSMDP6 REP- RSMDP15	BAT description and references are presented in Section 7. Section 10.8 references optioneering reports and states the BAT selected options for GDA.
Wastes should be quantified, characterised and segregated to facilitate effective onward processing.	REP - ENDP10 REP - RSMDP8 REP - RSMDP9 SAP - RW.4 SAP - ENM.5	Section 10.3 identifies segregation as close to source as practicable and characterisation to support all stages of the waste management process. Appendix A presents a summary waste inventory. Appendix B discusses monitoring, sampling and measurement and segregation.

Hitachi-GE Waste Management Principles	References	Considered in this document
Radioactive solid waste should be processed into a passively safe state as soon as is reasonably practicable and stored in accordance with good engineering practice.	REP- RSMDP11 SAP - RW.6	Sections 10 and 11 describe management and interim storage options that render the waste into a passively safe state as soon as is reasonably practicable Referenced PCSR and Basis of Safety Case (BSC) documents consider processing to a passively safe waste form and the minimisation as far as practicable of waste accumulation.
Accumulation of radioactive waste on site should be minimised (recognising cases where storage is required for decay purposes), and the waste storage systems should be designed to: • minimise release to the environment in normal operation, fault and accident conditions; • prevent the spread of contamination from leakage, and; • incorporate leak detection and alarm capability where appropriate.	REP – ENDP3 REP – ENDP15 REP- RSMDP10 SAP - RW.3 &5 SAP - ECV.1 SAP - ECV.2 SAP - ECV.4 SAP - ENM.6	
Dose to workers and the public should be minimised during active commissioning, operation, decommissioning and onsite storage.	SAP - RP.1	Section 7.2 references the Radiological Protection PCSR.
Designs of radioactive waste discharge systems (from treatment and storage facilities) shall have appropriate monitoring and sampling arrangements, and where necessary, provision for third party monitoring.	REP- RSMDP12 REP- RSMDP13 REP - ENDP14 SAP - ESR.8	Sections 8 and 9 identify liquid and gaseous waste monitoring and sampling points. Appendix B: Sampling and Monitoring discusses monitoring, sampling and measurement and references to the Radioactive Solid Monitoring Requirements document [Ref-10].
Waste packages should be accessible during interim storage.	SAP - ENM.7	Sections 10.4.4, 11.5 (ILW) and 11.6.1 (SF) state that packages will be retrievable for inspection, assay or remediation as required.

Hitachi-GE Waste Management Principles	References	Considered in this document
Records of all radioactive waste disposed of or accumulated on site should be maintained in a secure and accessible form.	REP- RSMDP14 SAP - RW.7	Sections 8.5, 9.4, 10.3.3 and 11.9 describe the requirement for the management and preservation of records.
A decommissioning plan should be prepared to demonstrate that it can be safely decommissioned	REP - DEDP1 REP - DEDP2 REP - DEDP3 SAP – DC.1	Section 10.9 references the PCSR decommissioning document, Chapter 31 [Ref-11] that presents current plans.

A number of REPS are identified as having relevance to waste management strategy development but are not easily aligned to the Hitachi-GE principles listed in the table above. These REPS are presented in Table 4.2-2.

Table 4.2-2: Other Waste Management Relevant REPs

REP	Description	Comment
RSMDP5	Actions having Irreversible Consequences	This document outlines the thorough and considered philosophy underpinning all radioactive waste management decisions. The application of BAT will ensure a robust decision making process.
ENDP4	Environmental Protection Functions and Measures	The liquid and gaseous management systems described in Sections 8 and 9 are designed to protect the environment. The defined management approaches for solid waste conditioning and storage and consignment to other facilities will ensure adequate environmental protection.
ENDP5	Human Factors	Human Factors (HF) considerations have and will be taken into account in the design development of the waste management facilities. Sections 8.1, 9.1 and 11 refer to PCSR Chapter 27 [Ref-12] which describes the HF Integration (HFI) process.
ENDP6	Engineering Codes and Standards	Environmental protection measures have been and will be designed, manufactured, constructed, installed, commissioned, quality assured, maintained, tested and inspected to the appropriate standards
ENDP7,8,9, 11	Reliability, Ageing and Degradation, Fault sensitivity, Maintenance, Inspection, Testing.	Not explicitly covered for plant systems in this document. Reliable environmental protection measures have been and will be incorporated into the UK ABWR and associated waste management facilities' design development and operation. Adoption of BAT will lead to implementation of

REP	Description	Comment
		reliable and maintained systems. The RWM LoC process, which is referred to, requires the longevity of waste packages and waste forms with predictable evolution.
ENDP16	Ventilation Systems	The Heating Ventilating and Air Conditioning (HVAC) and OG systems are considered in Section 9. Secondary wastes such as filters are included in the solid waste strategy.

5. Assumptions

The development of this waste management strategy is based on the following high level assumptions:

- The generic site comprises one reactor unit.
- The design basis for the UK ABWR fuel is to use the GE14 type (GNF's BWR Fuel design).
- Government policy, standards, legislative and regulatory environments remain unchanged, or changes pending have no significant impact.
- Strategies detailed within these arrangements will reflect only currently available technologies.
- Definitions of waste categories will remain unchanged.
- It is assumed that SF will not be reprocessed but will be stored, packaged and disposed of accordingly.
- Because the Geological Disposal Facility (GDF) for Higher Activity Waste (HAW: Intermediate Level Waste (ILW) and High Level Waste (HLW), including SF) is still only at a conceptual stage and detailed packaging requirements are not available, the focus of this strategy is to ensure that HAW can be safely stored on-site for an extended interim period of many decades.
- The Low Level Waste Repository (LLWR) Ltd. (or a successor) is available throughout the operational and decommissioning phases and its Waste Acceptance Criteria (WAC) continue to apply unchanged. LLWR Ltd. offers a well-recognised service for the whole UK nuclear industry. It is currently used by many operational sites in the UK and also by the legacy sites. However, there are a number of other facilities which can be used for waste disposals which are not listed in this document. The references to LLWR Ltd. are assumed for GDA and to enable the obtaining of an 'Acceptance in Principle' for management/disposal of Very Low Level Waste (VLLW) and Low Level Waste (LLW) based upon the services provided by LLWR Ltd. When appropriate the application of BAT [Ref-8], Argument 4b, will be implemented by the licensee to determine the best route for specific wastes, when other facilities and techniques for management of VLLW and LLW will be included.
- Non-aqueous radioactive liquid wastes are excluded from the aqueous liquid treatment and discharge to environment route and require export from site for specialist disposal. Their management is therefore considered alongside solid radioactive waste.
- This strategy assumes that the options presented can be used by utilities to demonstrate that the design represents BAT. The intention is to preserve as much flexibility as possible whilst providing confidence that BAT solutions can be identified by utilities in the future. This is judged to be sensible given the range of uncertainties at this stage. In particular, issues relating to the future treatment and transport of certain wastes may need to be resolved via consultations with RWM.

6. Regulatory Context

The regulatory framework will be as currently applicable to UK Nuclear facilities. This framework is largely non-prescriptive and a future operator must demonstrate to the Regulators that they fully understand the hazards and risks associated with their operations and know how to control and reduce them. Similarly, they are obliged to assess and minimise their impact on the environment.

In managing radioactive wastes in the UK, the main stakeholders for Hitachi-GE and their respective responsibilities are:

- Government – To determine policy, in the light of international agreements and guidance, and prepare statutory legislation.
- Regulators – To enforce the law and pay cognisance to Government policy and publish guidance which interprets Government policy.
- Operators – To implement appropriate waste management strategies, in compliance with Government policies and legislation and regulatory requirements/guidance.

The main policies, principles, guidance and regulations that relate to waste management and decommissioning in the UK are identified below:

- International Directives and initiatives
  - The OSPAR Convention
  - The Basic Safety Standards Directive (Council Directive 2013/59/EURATOM).
  - Euratom Treaty Article 37
- National Policy
  - UK Strategy for Radioactive Discharges 2011-2020
  - Managing Radioactive Waste Safely – Proposals for developing a policy for managing solid radioactive waste in the UK
  - Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom, By Defra, DTI and the Devolved Administrations, March 2007
- National Legislation
  - Nuclear Installations Act 1965
  - Environmental Permitting Regulations – Radioactive Substances Regulation 2010/2011
  - Ionising Radiation Regulations 1999
- Regulatory Guidance
  - Radioactive Substances Regulation - Environmental Principles (REPs) [Ref-2]
  - Safety Assessment Principles (SAPs) [Ref-3]
  - Guidance to Inspectors on the Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites
  - Environmental Permitting Guidance Radioactive Substances Regulation: For the Environmental Permitting (England and Wales) Regulations 2016

6.1 P&ID Requirements

The P&ID requirements relating to the Radioactive Waste Management Arrangements are reproduced below:

'A detailed description of the radioactive waste management arrangements'

Include:

Identification of the strategic considerations with respect to radioactive waste management which underpin the design.

A description of how radioactive wastes and spent fuel will arise throughout the facility's lifecycle (including decommissioning) and your plans for how they will be managed and disposed of, to encompass:

Sources of radioactivity and matters which affect wastes arising;

Gaseous, aqueous and other wastes.

A description of how the production, discharge and disposal of radioactive waste will be managed to protect the environment and to optimise the protection of people.

[Ref-1], Table 1, Item 4

'Quantification of radioactive waste disposals'

Include:

Provide quantitative estimates for normal operation of:

Arisings of combustible waste and disposals by on-site or off-site incineration;

Arisings of other radioactive wastes (by category and disposal route (if any)) and spent fuel;

'Normal operation' includes the operational fluctuations, trends and events that are expected to occur over the lifetime of the facility, such as start-up, shutdown, maintenance, etc.

[Ref-1], Table 1, Item 5, bullets 2 & 3

'A description of the sampling arrangements, techniques and systems for measurement and assessment of discharges and disposals of radioactive waste'

Include:

Details of in-process monitoring arrangements, as well as those for final ... disposals of non-aqueous liquid and solid wastes.

[Ref-1], Table 1, Item 6, bullet 1

6.2 Alignment with the REPs

Hitachi-GE's 'Alignment with the Radioactive Substances Regulation Environmental Principles' report [Ref-13] details the approach undertaken by Hitachi-GE to reviewing and taking account of each REP considered relevant to the requesting party's GDA submission.

Section 4.2 of this RWMA document presents the alignment of Hitachi-GE principles with relevant regulatory principles (REPS and SAPS) in a waste management strategy context and indicates where and how the principles have been considered.

6.3 Consideration of Site Licence Conditions

Compliance with defined licence conditions is required to ensure the safe operation and maintenance of a nuclear installation. Licence Conditions (LC) pertinent to the management of solid waste on a licenced site and the safe, continued implementation of the site solid waste strategy throughout the lifetime of the site include:

LC4: Restrictions on nuclear matter on the site, *"The licensee shall ensure that no nuclear matter is stored*

on the site except in accordance with adequate arrangements made by the licensee for this purpose."

LC5: Consignment of nuclear matter, *"The licensee shall not consign nuclear matter(other than excepted matter and radioactive waste to any place in the UK other than a relevant site except with the consent of ONR" and "the licensee shall keep a record of all nuclear matter (including excepted matter and radioactive waste) consigned from the site…"*

LC6: Documents, records, authorities and certificates, *"The licensee shall make adequate records to demonstrate compliance with any of the conditions attached to this licence."*

LC28: Examination, inspection, maintenance and testing, *"The licensee shall make and implement adequate arrangements for the regular and systematic examination, inspection, maintenance and testing of all plant which may affect safety."*

LC32: Accumulation of radioactive waste, *"The licensee shall make and implement adequate arrangements for minimising so far as practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated."*

LC34: Leakage and escape of radioactive material and radioactive waste, *"The licensee shall ensure, so far as is reasonably practicable, that radioactive material and radioactive waste on the site is at all times adequately controlled or contained so that it cannot leak or otherwise escape from such control or containment."*

LC35: Decommissioning, *"The licensee shall make and implement adequate arrangements for the decommissioning of any plant or process which may affect safety."*

LC36: Organisational capability, "*The licensee shall provide and maintain adequate financial and human resources to ensure the safe operation of the licensed site" and, "the licensee shall make and implement adequate arrangements to control any change to its organisational structure or resources which may affect safety."*

The ONR is responsible for issuing site licences as well as monitoring an operator's compliance with the conditions. The ONR has issued a set of SAPs [Ref-3] as guidance to inspectors and site licensees for the assessment of safety cases.

7. The Decision Making Process

The application of BAT to the UK ABWR design will be demonstrated through the Claim, Argument, and Evidence approach. The methodology is already widely used in the nuclear and other high hazard industries in the preparation of safety cases and is described in detail in [Ref-14] and [Ref-8].

Hitachi-GE has developed a methodology for demonstrating the application of BAT which breaks the process down into the main BAT-related permit conditions. Hitachi-GE will therefore be able to demonstrate that it has done everything possible (considering proportionality) to:

- Prevent and minimise (in terms of radioactivity) the creation of radioactive waste;
- Minimise (in terms of radioactivity) discharges of gaseous and aqueous radioactive wastes;
- Minimise the impact of those discharges on people, and adequately protect other species;
- Minimise (in terms of mass and volume) solid and non-aqueous liquid radioactive wastes and spent fuel;

- Select the optimal disposal routes (taking account of the waste hierarchy and the proximity principle) for those wastes; which also includes the suitability of disposal for those wastes where there is currently no available disposal route.

The Hitachi-GE Demonstration of BAT report [Ref-8] presents the arguments and evidence for the following claims:

Claim 1: Eliminate or Reduce the Generation of Radioactive Waste

Claim 2: Minimise the Radioactivity in Radioactive Waste Disposed to the Environment

Claim 3: Minimise the Volume of Radioactive Waste Disposed of to Other Premises

Claim 4: Selecting the Optimal Disposal Routes for Wastes Transferred to Other Premises

Claim 5: Minimise the Impact on the Environment and Members of the Public from Radioactive Waste that is disposed of to the Environment

Hitachi-GE is confident that the evidence presented within the Demonstration of BAT report shows that the best available technologies have been selected.

7.1 The Waste Hierarchy

Application of the Waste Hierarchy as illustrated in Figure 7.1-1 is key to BAT selection and aims to encourage the management of waste materials in order to reduce the amount produced, and to recover maximum value from the wastes that are produced. It is not applied as a strict hierarchy as many complex factors influence the optimal management for any given waste material. However, as a guide, it encourages the prevention of waste, followed by the reuse and refurbishment of goods, then value recovery through recycling. The next option is energy recovery, an important level in the hierarchy as many materials have significant embedded energy that can be recovered. Waste prevention, reuse, recycling and recovery are collectively defined by the Organisation for Economic Co-operation and Development (OECD) as waste minimisation. Finally, waste disposal should only be used when no option further up the hierarchy is possible.

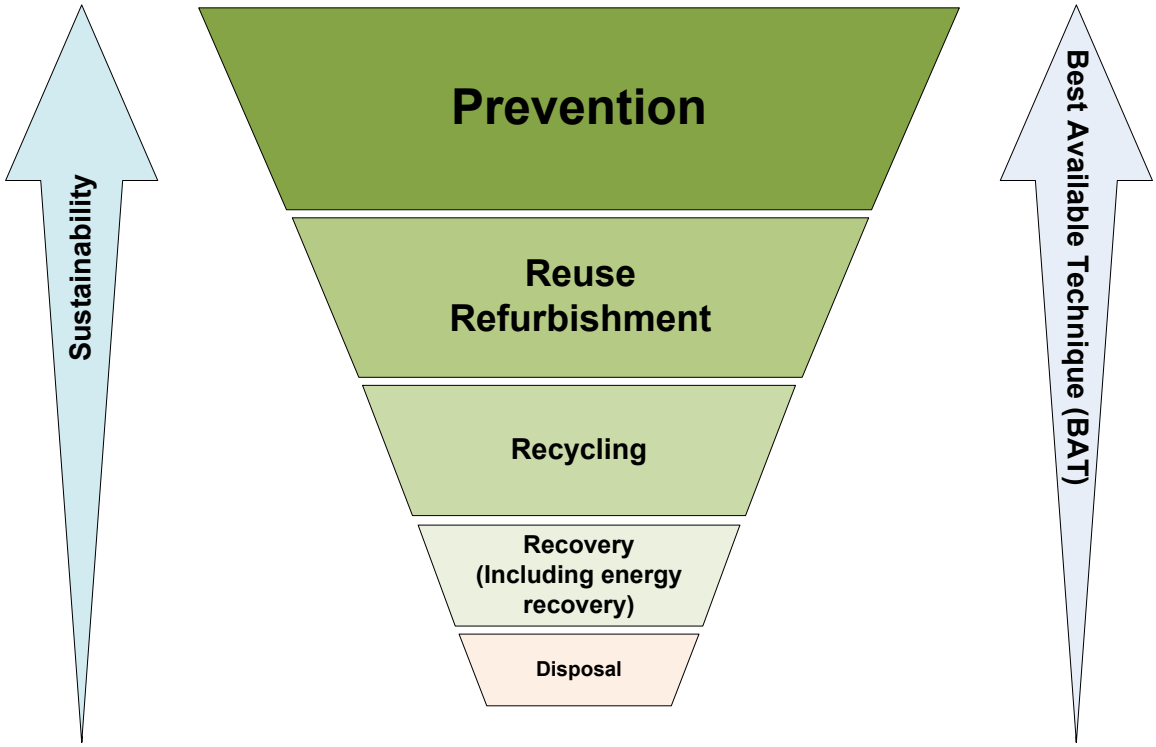


Figure 7.1-1: Waste Hierarchy

7.2 ALARA / ALARP

The application of BAT will consider keeping the dose uptake of workers the public and the environment As Low As Reasonably Achievable (ALARA), taking into account economic and social factors. Where the safety of on-site workers is implied, the term ALARA is considered interchangeable with the term As Low As Reasonably Practicable (ALARP) which is typically used in a health and safety context.

As a part of the BAT justification, the waste management options that go forward for further design development will ensure dose uptake is ALARA during design through the application of radiological protection measures as described in the Generic PCSR Chapter 20: Radiological Protection [Ref-15]. The key sections are: 20.4 *Strategy to Ensure that the Exposure is ALARP*, 20.5 *Protection and Provisions against Direct Radiation and Contamination* and 20.6 *Radiation and Contamination Monitoring of Occupational Radiation Exposure*. Radiation Protection Advisers and Radioactive Waste Advisers are integral to the waste management design process.

8. Liquid Radioactive Waste Management Strategy

Liquid radioactive waste is produced during the commissioning, operations, and decommissioning phases of the UK ABWR life. Commissioning of the UK ABWR unit will include commissioning of its liquid waste management system and is therefore considered similar to the operations phase in this strategy document.

8.1 Operations

The systems in place for the management and treatment of liquid radioactive discharges are described in the PCSR Chapter 18: Radioactive Waste Management, section 18.5 [Ref-7] and underpinned by

Demonstration of BAT [Ref-8].

PCSR Chapter 18, section 18.3.1.1 states, "The main environmental function of the Liquid Waste Management System (LWMS) is to ensure that the activity and volume of discharges to the environment are kept to a minimum and within the discharge consent."

HF considerations have and will be incorporated in the design of each facility of the UK ABWR under the HF Integration Plan. Where human factors are relied upon as part of the BAT case, these instances will be fed into the HFI process outlined in PCSR Chapter 27: Human Factors [Ref-12].

The strategy to manage the aqueous liquid radioactive waste generated through operation of the generic UK ABWR is to apply the Hitachi-GE design methodology as developed and proven through operational experience in Japan and described in reference document: Generic PCSR Chapter 18: Radioactive Waste Management, section 18.5 [Ref-7].

Subsequent sections of this chapter give a brief description of the LWMS sub-systems and identify the relevant BAT demonstration.

The Liquid Radioactive Waste Strategy covers the following liquid radioactive waste systems which are illustrated in Figure 8.1-1:

- Low Chemical Impurities Waste (LCW) Treatment System in Radwaste Building (Rw/B)
- High Chemical Impurities Waste (HCW) Treatment System in Rw/B (including discharge)
- Laundry Drain (LD) Treatment System in Service Building (S/B) (including discharge)
- Controlled Area Drains (CAD) System in Rw/B (including discharge)

The Radioactive Drain (RD) Transfer System collects waste waters and directs them to the relevant system.

The following closed loop reactor water systems are also briefly discussed as, although not waste water systems, they include water treatment processes that generate secondary solid wastes and feed in to the LCW system:

- Condensate Water Clean-Up System in Turbine Building (T/B)
- Reactor Water Clean-Up (CUW) System in Reactor Building (R/B)
- Fuel Pool Cooling and Clean-up System (FPC) System and Suppression Pool Clean-Up (SPCU) System in R/B
- Waste Water Treatment Secondary Waste Buffer Storage

The Secondary wet-solid wastes generated by both LWMS treatment systems and the Primary Circuit and FPC water treatment systems are identified in the system descriptions given in this Section. The secondary wastes are temporarily stored prior to transfer to the solid waste management system for treatment, packaging, interim storage (as required) and consignment to a disposal facility. PCSR Chapter 18, sections 18.5.1.5 and 18.5.1.6 [Ref-7] describe the Spent Sludge system (SS) and the Concentrated Waste (CONW) systems respectively (see also sections 8.1.3.1 and 8.1.6.4 of this RWMA).

Operation of the UK ABWR will be for 60 years. It will be the responsibility of the future site operator to define the future liquid radioactive waste strategy based upon site specific considerations and future technological advances to maintain BAT.

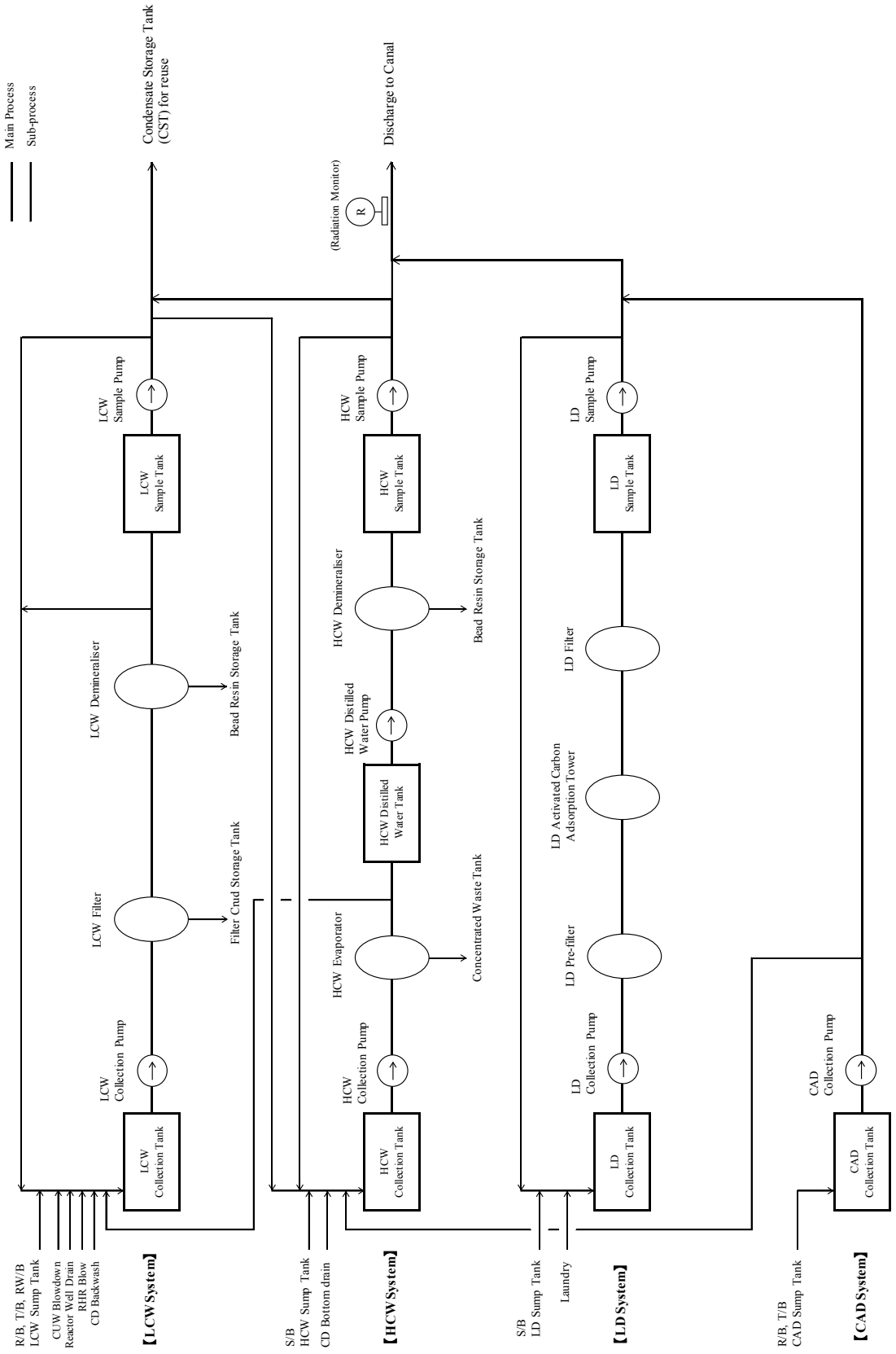


Figure 8.1-1: Liquid Radioactive Waste System Flow Diagram [Ref-8]

8.1.1 Radioactive Drain (RD) Transfer System

The RD Transfer System is used to transfer waste water collected in the controlled areas in the R/B, T/B and S/B into collection tanks in individual LWMS subsystems installed in the Rw/B. The RD Transfer System comprises sump tanks, sump pumps, piping, valves, and appropriate instrumentation.

8.1.1.1 RD Process description

Equipment Drains – collect radioactive or potentially radioactive waste water from Primary Circuit system and equipment in the R/B and T/B (including from reactor blow downs during outages), from the SFP system and equipment, and also from system and equipment in the Rw/B. This waste water is generally expected to have low levels of impurities and, therefore, is normally automatically pumped from the equipment drain sumps to the LCW Treatment System Collection Tank.

Chemical Drains - collect the chemical waste generated at the laboratory in the S/B and collect water such as from the condensate demineraliser drains. The waste water generated at the laboratory is collected into the Drain Sump and is automatically pumped to the HCW system. Waste water drained from the condensate demineraliser is collected in the HCW collection tanks.

Laundry Drains (LD) - collect waste water from the laundry and from the personnel shower and hand washing facilities in the S/B. This waste water is automatically transferred to the LD Collection Tanks. The LD waste water stream includes detergents and organic materials and is kept separate from the other waste water streams due to its unsuitability for re-use in the reactor system.

Controlled Area Drains (CAD) - collect waste water from other systems (e.g. local HVAC systems) in the Radiation Controlled Areas (RCA) in the R/B and T/B. The waste water collected from the RCAs is potentially contaminated. This water is automatically transferred to the CAD Collection Tank.

8.1.1.2 RD Transfer System Demonstration of BAT

The report on Demonstration of BAT [Ref-8], Section 5.1.10, Argument 1j, demonstrates that the containment systems in the reference plant design are considered to represent BAT, for example by the reduction in potential leakage points, the reduction wherever possible of pipe lengths, the preference for welded joints where possible and high specification leak tightness of joints, valves etc., and the inclusion of appropriate leak detection equipment.

8.1.2 Low Chemical Impurities Waste (LCW) Treatment System

The LCW Treatment System is housed in the Rw/B and is one of two subsystems (the other being the HCW subsystem) which are used to treat radioactively or potentially radioactively contaminated waste water. The LCW system is designed to allow the efficient treatment of relatively large volumes of waste water containing low levels of both insoluble and soluble impurities.

The LCW system processes waste water from equipment drains. The main sources of this waste are the primary coolant system, FPC and plant make-up water system. Water from the CUW system is discharged to the LCW system when either excess water is removed from the CUW system during reactor start-up and shutdown operations (CUW blowdown). The LCW system treats the waste waters which are then returned to the Condensate Storage Tank for reuse.

8.1.2.2 LCW Process description

The LCW system consists of filters for the removal of insoluble impurities, demineralisers for the removal of soluble impurities, and sampling tanks.

Waste water collection - The LCW system processes waste water from equipment drains. The main sources of the waste water are the reactor primary coolant system, the FPC and the plant make-up water system. Prior to processing, a sample of the waste water can be analysed if required to confirm its properties (e.g. chemical impurity). If the waste water properties mean it is not suitable for treatment in the LCW system, the waste water is transferred to the HCW system.

Filtration - Filters are used to remove insoluble impurities in the LCW. When the differential pressure across the filter increases, the filter is backwashed (water washed, gravity drained and air scoured) to remove the particulate. The crud generated is transferred to the SS for collection and storage before being processed in the Rw/B. When exhausted, the filters are raised out of the filter vessel, monitored and prepared for transfer to the dry solid LLW waste processing system.

Demineralisation - Following filtration, the water is passed through a mixed bed demineraliser packed with bead type ion exchange media to remove soluble impurities. LCW water is sampled following demineralisation. The demineraliser resins are changed when they reach pre-set plant operations limits, for example a reduced ion exchange capability, an operational lifespan or a determined radiation dose rate: the parameters will be determined by the site operator based upon the demineraliser design, ion exchange media used, operational conditions and handling facility safety cases. The spent bead resin is discharged from the demineraliser vessel to the SS for collection and storage before being processed in the Rw/B.

Sample and Waste water re-use - Treated water is collected in a sample tank, where a representative sample of water is analysed to confirm it meets the criteria for re-use in the reactor. If the treated water does not meet the appropriate criteria, it can be routed back to the LCW Collection Tank and the treatment process repeated (potentially multiple times until the criteria are met). Once the treated water has been confirmed to meet the appropriate criteria it is normally sent to the Condensate Storage Tank (CST) for reuse as reactor Primary Circuit or SFP make-up water. There is no radioactivity criterion for water treated in the LCW system, as the system is operated solely on the level of insoluble and soluble impurities within the water.

Recirculation and re-use ensures that there is no discharge to sea other than via the HCW system.

8.1.2.3 LCW Secondary Solid Waste

The secondary solid wastes produced by the LCW system process are identified above and described in the following sections of this document:

- Hollow fibre membrane filters; Appendix A, Section 2.2, Table A2.2-5
- Filter crud; Appendix A, Section 2.4, Table A2.4-1
- Spent bead demineraliser resin; Appendix A, Section 2.2, Table A2.2-2

The solid ILW and LLW radioactive waste treatment strategy and associated facilities are described in Sections 10 and 11 of this RWMA document.

8.1.2.4 LCW Demonstration of BAT

The Demonstration of BAT [Ref-8], Section 5.1.8.4 Evidence: LCW Treatment System demonstrates that the LCW Treatment System represents BAT. Hitachi-GE undertook an assessment to compare the different treatment technologies available for the LCW Treatment System. The assessment compared demineralisers (ion exchange), reverse osmotic membrane and cross-flow filtration against a range of criteria such as operational experience, reliability, maintainability, solid waste generation, decontamination factor and cost. Overall demineralisers scored significantly higher than the other two techniques, outperforming them in the following areas:

- lowest impact on the generation of solid waste
- lowest capital cost
- highest reliability safety
- highest maintainability
- highest resistance to radiation
- low/no requirement for chemicals

The assessment therefore identified the use of demineralisers, as well as a filter, as the preferred option for treatment of LCW.

8.1.3 High Chemical Impurities Waste (HCW) Treatment System

The HCW Treatment System is housed in the Rw/B and is one of two subsystems (the other being the LCW subsystem) which are used to treat radioactively or potentially radioactively contaminated waste water. The HCW Treatment System is designed to allow the efficient treatment of waste water containing high levels of soluble impurities.

Treated water is either transferred to the Condensate Storage Tank for reuse or, in limited circumstances where there is not the capacity in the reactor system for re-use, disposed of to the environment following monitoring.

8.1.3.1 HCW Process Description

The HCW system comprises an evaporator for distillation and removal of impurities, a demineraliser for removal of soluble impurities and sampling tanks. Filtration is unnecessary as the evaporator retains solid matter in the concentrate.

Waste water collection - The main source of HCW is waste water collected by the chemical analysis lab (hot lab) drains in the S/B and the condensate demineraliser drains. However, it is also possible to route waste water consigned to the CAD system to the HCW system depending on the expected level of impurities (including non-radiological contamination) it contains. Effluent will be treated in the HCW treatment system in “batches”. HCW water can be sampled prior to processing.

Evaporation - The evaporator is effective at concentrating and containing the majority of the radioactivity initially present in the HCW into a sludge-like concentrate. The evaporated water is collected in the vapour

phase, condensed and passed to the demineralisation step. Solids with concentrated radioactivity are retained in the evaporator. The sludge-like concentrate is transferred to the concentrated waste (CONW) system. The CONW system receives and stores concentrated waste from the bottom circuit of the HCW evaporator and then sends it to the Wet-solid LLW solidification system in the Rw/B (see also section 11.2).

Demineralisation - Following treatment in the evaporator, the water is collected in the HCW distilled water tank and then passes through a mixed bed demineraliser packed with bead type ion exchange media to remove soluble impurities which could potentially be carried over from the evaporator. The demineraliser ensures that the concentration of fission products and activation products in the water is sufficiently low in the event that the HCW is required to be disposed of to the environment. The spent bead resin is discharged from the demineraliser vessel to the SS for collection and storage before being processed within the Rw/B.

Sample and water re-use or discharge - Treated water is collected in a sample tank where a representative sample of water is analysed to confirm it meets the criteria for re-use in the reactor. If the water does not meet the criteria, it is returned to the HCW Collection tank and the treatment process repeated (potentially multiple times until the criteria are met). Once the treated water meets the criteria, the water is discharged to the Condensate Storage Tank for reuse as reactor Primary Circuit or SFP make-up water. Only if the treated water volumes exceed Primary Circuit and SFP water make-up requirements and is within discharge limits that will be defined in the EP-RSR Permit and is discussed in the Quantification of Discharges and Limits document [Ref-16], is the treated water routed to the main discharge line to be discharged to the environment. If treated water does not meet the discharge criteria, it can be routed back through the HCW treatment process (potentially multiple times) until the discharge criteria are met.

8.1.3.2 HCW Secondary Solid Waste

The secondary solid wastes produced by the HCW system process are identified above and described in the following sections of this document:

- Evaporator concentrate; Appendix A, Section 2.2, Table A2.2-3
- Spent bead demineraliser resin; Appendix A, Section 2.2, Table A2.2-2

The wet solid LLW radioactive waste treatment strategy and associated facilities are described in Sections 10 and 11 of this RWMA document.

8.1.3.3 HCW Demonstration of BAT

The Demonstration of BAT [Ref-8], Argument 2h: Evaporation of High Conductivity Liquids demonstrates that the HCW Treatment System represents BAT. Hitachi-GE undertook a study to determine which treatment technology to use on the HCW System. The study assessed a number of different treatment techniques; evaporation, reverse osmosis membrane, ion exchange, ultra-filtration and micro filtration and gave each technique a score for a range of criteria including operational experience, reliability, maintainability, solid waste generation, decontamination factor and cost. Overall, evaporation scored highest in the study. The evaporation technique outperformed the other techniques in important areas including;

- The highest decontamination factor of 10^3 to 10^4.
- The lowest impact on solid waste generation due to the evaporator's high volume reduction performance.
- Reliability safety due to the evaporator's extensive operating performance.

The evaporation technique performed less well in terms of capital cost and layout impact (size of installation) however these were deemed less significant compared to the main benefits identified above.

8.1.4 Laundry Drain (LD) Treatment System

The LD Treatment System processes waste water originating from the laundry and the S/B showers and hand washing facilities. These waste water streams contain detergent, suspended solids and organic material, as well as potentially low levels of radioactive crud, and are therefore unsuitable for re-use in a reactor system.

8.1.4.1 LD Process Description

To remove these impurities the water is first passed through a packed bed pre-filter, followed by an activated charcoal adsorption unit and a pre-coat carbon filter.

Waste water collection - The LD system will collect waste water from the on-site laundry and S/B active showers and hand washing facilities. LD waste water can be sampled prior to processing.

Pre-Filtration - The pre-filter is a vessel with layers of hollow fibre blanket type material which acts as a coarse filter to collect hair and other larger sized suspended solids. The suspended solids are removed from the system as waste sludge together with the filter media, monitored and prepared for transfer to the dry solid LLW processing system.

Activated Carbon Adsorption units - are bed filters containing bead activated carbon (BAC), which adsorb organic impurities and trap the smaller suspended solids that pass through the pre-filters. The adsorbed impurities and suspended solids are removed from the system together with the (exhausted) activated carbon filter when the differential pressure becomes high. The activated carbon is retrieved and monitored into 210 litre drums for transfer to the solid LLW processing systems.

Pre-Coat Carbon Filters - The pre-coated filters consist of an array of cartridges with a fabric 'sock' which is pre-coated in Granular Activated Carbon (GAC), the purpose of which is to trap small-sized suspended solids. The waste sludge is removed from the system together with the filter media. The GAC is discharged into a collection drum and monitored. The drums are transferred to the solid LLW processing systems.

Discharge - The treated waste water is collected in a sample tank, where a representative sample of the water is analysed to confirm that the residual level of radioactive contamination meets the criteria for discharge to the environment that will be defined in the EP-RSR Permit and is discussed in the Quantification of Discharges and Limits document [Ref-16]. Treated water which meets the discharge criteria for the LD Treatment System will be routed to the main discharge line. If treated water does not meet the discharge criteria, it can be routed back to the LD Collection Tank and the treatment process repeated (potentially multiple times) until the discharge criteria are met.

8.1.4.2 LD Secondary Solid Waste

The secondary solid wastes produced by the LD system process are identified above and described in the following sections of this document:

- Hollow fibre filter material; Appendix A, Section 2.2, Table A2.2-4

- BAC and GAC; Appendix A, Section 2.2, Tables A2.2-4

The solid LLW radioactive waste treatment strategy and associated facilities are described in Sections 10 and 11 of this RWMA document.

8.1.4.3 LD Demonstration of BAT

The Demonstration of BAT report [Ref-8] Argument 2e: Configuration of Liquid Management Systems explains the segregation of the LD system from the other liquid radioactive waste systems. The segregation of the stream and its specific treatment facilities are considered BAT.

8.1.5 Controlled Area Drains (CAD) System

The CAD System collects water from the local air-conditioning system drains in the R/B and T/B, and also from the potentially contaminated drains of various equipment systems in the controlled areas of the R/B and the T/B. The system is comprised of liquid waste collection tanks, collection pumps, piping, valves and measuring and control equipment. Liquid waste in the CAD System is not expected to be radioactive but has the potential to be contaminated.

8.1.5.1 CAD Process Description

Waste water collection and discharge - The collected waste water is pumped to the CAD Collection Tank where it is sampled to confirm it contains no significant radiological contamination or unacceptable chemical contamination. Water which meets the discharge criteria will be routed to the main discharge line. If the water is found to contain any significant radiological contamination or unacceptable chemical contamination, then the operator routes the water to the HCW system for treatment.

8.1.5.2 CAD Demonstration of BAT

The Demonstration of BAT report [Ref-8] Argument 2e: Configuration of Liquid Management Systems demonstrates that typically CAD waste water is monitored and shown to be non-radioactive and suitable for discharge directly to the environment without processing. However, if radioactive contamination is found then the water is diverted to the HCW system for treatment. The HCW BAT argument is addressed in section 8.1.3.3.

8.1.6 Water Clean-Up Systems

8.1.6.1 Condensate Water (CW) Clean-Up System

The CW Clean-Up System uses filtration and demineralisation to treat condensed water that has passed through the turbines. Once treated, the water is returned to the reactor. Secondary wastes include hollow fibre membrane filters from the Condensate Filter (CF), crud and demineraliser resin from the Condensate Demineraliser (CD). The crud and demineraliser resin are collected and stored in the SS before being processed within the Rw/B.

8.1.6.2 Reactor Water Clean-Up (CUW) System

The CUW System continuously draws water from the reactor and passes it through the filter-demineralisation system to control and remove impurities. Once treated, the water is returned to the reactor. Secondary wastes include powder ion exchange resin which is collected and stored in the SS before being processed within the Rw/B.

8.1.6.3 Fuel Pool Cooling and Clean-up System (FPC) System and Suppression Pool Clean-up (SPCU) System

The FPC System removes impurities from Spent Fuel storage Pool (SFP) water as well as decay heat from the spent fuel. The FPC System maintains the pool water clarity to aid removal of the fuel and servicing of the reactor vessel. Once treated, the water returns to the SFP.

The SPCU System shares the same filter demineraliser as the FPC, removing impurities from the pool water in the suppression chamber. Secondary wastes include powder ion exchange resin which is collected and stored in the SS before being processed within the Rw/B.

8.1.6.4 Water Clean-up Systems Secondary Solid Waste

The secondary solid wastes produced by the water clean-up system processes are identified above and described in the following sections of this document:

- CW hollow fibre membrane filters; Appendix A, Section 2.2, Table A2.2-4
- CW filter crud; Appendix A, Section 2.4, Table A2.4-1
- CW, CUW, FPC spent powder demineraliser resin; Appendix A, Section 2.2, Table A2.4-2

The solid ILW and LLW radioactive waste treatment strategy and associated facilities are described in Sections 10 and 11 of this RWMA document.

8.1.6.5 Demonstration of BAT

The closed loop reactor water systems described above are discussed in the Demonstration of BAT document as evidence in Argument 1h: Recycling of water to prevent discharges.

8.2 Secondary Liquid Waste from the Solid Waste Management Facilities

The solid waste management facilities, as described in Section 11 of this RWMA document, will produce limited quantities of potentially radioactively contaminated waste water, primarily from personnel washing facilities. These secondary water wastes are identified in the individual facility descriptions. The waste water will be collected at the facility, monitored and, dependent on site specific infrastructure, pumped or bowsered to the appropriate liquid waste treatment and disposal route.

8.3 Liquid Radioactive Waste during Decommissioning

The GDA baseline decommissioning plan and decommissioning waste management strategy are presented in the Generic PCSR Chapter 31: Decommissioning [Ref-11] and the Decommissioning Waste Management Topic Report [Ref-17]. The following decommissioning phases are considered:

- Phase 1: Before end of generation (Pre-closure preparatory work);
- Phase 2: Immediately after end of generation (SF management to Spent Fuel Interim Store (SFIS), Post Operational Clean Out (POCO) and system decontamination);
- Phase 3: Power Plant Decommissioning (dismantling and decontamination of plant, demolition and delicensing);
- Phase 4: SF, HLW and ILW storage period;
- Phase 5: HLW / ILW store emptying, repackaging and disposal;
- Phase 6: Spent Fuel storage and SFIS emptying, repackaging and disposal;
- Phase 7: Demolition and delicensing of the site.

For GDA the requirement for a liquid radioactive waste strategy is recognised. The future site specific strategy and methodology will be the responsibility of the future site operator based on the site operational history and site specific infrastructure to demonstrate BAT. The following sections propose an overview of the requirements of a liquid radioactive waste system for each decommissioning phase noted above. Table A2.7-4 in Appendix A presents details of the decommissioning liquid waste.

8.3.1 Phase 1: Before End of Generation (Pre-closure Preparatory Work)

Routine operation of the liquid radioactive waste systems continues.

The radioactive inventory of the systems will be evaluated. A safety assessment to consider the potential impact of decommissioning operations to workers, the public and the environment will be conducted. Regulatory submissions and applications for modified or new environmental permits will be prepared.

8.3.2 Phase 2: Immediately After End of Generation

The requirement for maintaining water volume and condition in the reactor and SFP systems continues until at least all fuel has been removed from those systems (CUW, FPC, and LCW) and placed into the SFIS.

8.3.2.1 Reactor Defueling

The retrieval and movement of SF and control rods to the SFP requires continued operation of the liquid radioactive waste systems with particular emphasis on the FPC system as fuel movements are increased.

SF will be transferred from the SFP to the SFIS after 10 years cooling which has the potential to overlap with the Phase 3 Power Plant Decommissioning operations. There will be continued operation of the liquid radioactive waste systems. Until drained, all water containing circuits will require treatment to ensure controlled, known conditions.

8.3.2.2 POCO

POCO is the removal of working fluids, resins and other operational material (radioactive and non-radioactive) at the end of the facility's operational life. Existing plant and processes will be used as far as practicable and resulting liquid waste will be treated within the existing LWMS system.

The turbine system will be isolated and the CF and CD become redundant. The CST or suppression pool water will remain in service to aid the management and distribution of retained water until the completion of RSW cutting in phase 3.

8.3.2.3 Installation of a Decommissioning Waste Management Facility

The installation of a Decommissioning Waste Management Facility will require the installation of a new system.

8.3.2.4 System Decontamination

The current baseline decommissioning plan assumes system decontamination of the Reactor Pressure Vessel (RPV), CUW and Reactor Heat Removal (RHR) systems in Phase 2 with the FPC being decontaminated in Phase 3 prior to SFP decommissioning. System decontamination typically uses an oxidation-reduction dissolution method. The system decontamination liquid is not expected to be compatible with the existing LCW treatment system. Subject to future licensee BAT and ALARP assessment, the reactor system will be isolated from the existing LCW and will use a bespoke liquid waste treatment plant for the treatment and recirculation of the decontamination liquid.

The water used for the chemical decontamination will be recirculated within the system after decomposition and purification steps. An example of the decontamination treatment equipment is shown in Figure 8.3.2-1. At completion of the decontamination process the liquid will be treated, sampled and discharged.

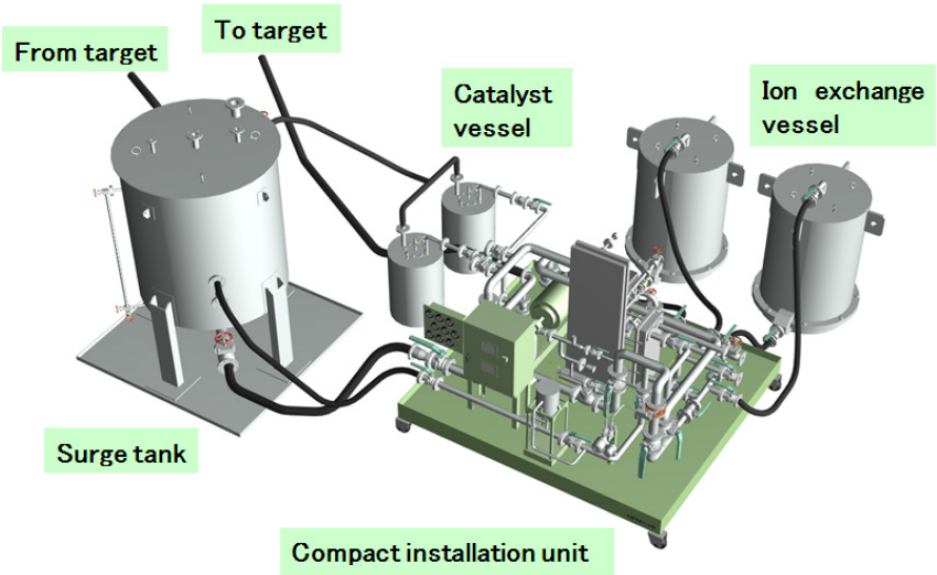


Figure 8.3.2-1: Example of System Decontamination Liquid Treatment System

8.3.2.5 Installation of a Temporary Liquid Waste Management System

A temporary liquid waste management system will be constructed and commissioned ahead of the Rw/B being removed from service.

8.3.3 Phase 3: Power Plant Decommissioning

8.3.3.1 Treatment of Reactor Internals (RIN) and RPV

Following system decontamination the RPV remains filled with water. The RIN will be cut free and, where practicable, size reduced under water in the flooded RPV. The RIN items will be transferred to a pool for further size reduction (segmentation), characterisation and segregation. Potential pool areas for use include the Dryer Separator Pool (DSP) and SFP (after completion of SF transfer to the SFIS). The baseline plan assumes use of the DSP. The retained water in the RPV and DSP systems, as well as providing cooling and shielding functions, also has the potential to be circulated, treated and re-used in applied cutting techniques if identified as BAT; for example as the source of water in an abrasive water jet technique. The water will be passed through filters installed in the RPV and cutting pools to ensure separation of activated particulate, helping maintain a controllable water chemistry and visual clarity for remote operations.

Once the DSP has been emptied of RIN it will be drained of water, decontaminated and prepared for RPV size reduction in air. The preferred option is that in-situ cutting of the RPV itself will use remote cutting techniques in air. The retained water level in the RPV will be gradually lowered to below the cutting level as the RPV is segmented. The resulting RPV segments will be transferred to the dry DSP for size reduction.

The cutting techniques selected will be appropriate to the characteristics of the items being cut and consider the secondary wastes produced both in the cutting operation and the water treatment requirements that follow.

The Reactor Shield Wall (RSW) is a concrete structure that encircles the RPV and provides radiation shielding. Cutting of the RSW will collect, recirculate and re-use the water used for the lubrication and cooling of the cutting element as practicable.

More than half of the total retained water is utilised for system decontamination and dismantling operations: 7870m^3 of the total retained water volume 11710 m^3 may be utilised in system decontamination, RIN, RPV and Reactor Shield Wall dismantling [Ref-17].

Table 8.3.3-1 presents the estimated discharges of treated retained water during the decommissioning period with reference to key decommissioning operations that utilise the retained water.

Table 8.3.3-1: System Retained Water Phased Discharge during Decommissioning

Work flow		**Discharge (m^3)**	**Retained water volume (m^3)**
Shutdown			11710
	(Treating the retained water in Rw/B)	500	11210
		500	10710
SF transfer to SFP		500	10210
		100	10,110
SF transfer to SFIS	System decontamination (RPV, CUW, RHR)	710	9400
	Reactor internals dismantling	1340	8060
	RPV dismantling	1850	6210
	RSW dismantling	1950	4260
	DSP dismantling	1410	2850
	FPC System decontamination and SFP demolition	2350	500
	Retained water discharge (CST)	500	0

Prior to discharge the waste waters will be treated by filtration and demineralisation using the replacement temporary treatment system commissioned at the end of Phase 2.

Secondary solid radioactive wastes will include sludge and swarf, demineraliser resins and solid items such as filters. The solid wastes will have similar characteristics to those produced during the site operations

phase and will follow similar waste treatment and disposal routes as presented in Sections 10 and 11 of this arrangements document. The final system decontamination methodology and required liquid waste treatment facilities will be developed and defined during the site pre-closure preparatory work. The design will include definition of techniques and estimated waste type and quantity.

8.3.3.2 Building Demolition

Building demolition will be carried out once the radioactive inventory has been removed from the main buildings.

Decommissioning operations will require continued operation of the HCW and LD systems for as long as they are required and available. Any ongoing requirement for treatment of potentially radioactive contaminated waste will be limited to personnel washing facilities, laundry requirements and small volumes of miscellaneous water wastes potentially generated from continued waste management and storage facilities. Treatment of these waste waters will be considered during the pre-closure planning phase and may include the installation of temporary collection and treatment equipment, the placement of contracts for off-site laboratory characterisation and off-site laundry services.

8.3.4 Phases 4, 5, 6: ILW Storage, Emptying and Disposal, HLW and SF Interim Storage, Repackaging and Disposal

The Solid Waste Facility (SWF), ILW Store (ILWS), HLW store, SFIS and the HAW/SF inspection and repackaging facility will be amongst the last buildings to be removed from site. These are planned to be dry facilities and therefore the only potentially radioactive liquid waste will be personnel washing facilities, laundry requirements and small volumes of miscellaneous water wastes. A waste water treatment system appropriate to the limited volumes and characteristics of the liquid wastes generated by the solid waste treatment facilities will be installed when appropriate.

The waste water management requirements for the subsequent ILWS, HLW store and SFIS emptying and deplanting phases are considered similar to those for the interim storage period.

Phase 7, demolition and delicensing, is not anticipated to produce radioactive liquid waste.

8.4 Monitoring, Sampling and Measurement

8.4.1 Sampling and Monitoring Locations

The sampling and monitoring locations are described in [Ref-18]. The Approach to Sampling and Monitoring document does not detail the sampling and monitoring equipment required as this needs to be BAT at the time of procurement. It does, however describe current methods and techniques that are deemed to be suitable.

8.4.1.1 In-process Sampling and Monitoring

Sections 8.1.1 to 8.1.6.5 of this strategy document describe in brief the liquid radioactive waste systems and indicate where sampling and analyses are applied to decide whether liquid is suitable for re-use, requires retreatment or meets permitted discharge limits.

8.4.1.2 Discharge Monitoring

Radionuclides to be measured at discharge are listed in [Ref-18] and compared to European Union (EU) commission recommendations.

Representative samples of the liquid effluent are retrieved from the discharge tank through the use of a sampling point on a recirculation line and proportional samplers on the liquid discharge line. Samples are analysed in a laboratory. In addition to sampling and analysis, a radiation monitor is installed in the liquid discharge line as an extra measure to prevent uncontrolled discharge to the environment. If anomalous radiation levels are detected, the line is automatically closed to prevent further discharge to the environment and an alarm sounded.

8.5 Waste Record Management

Recording the operation and performance of the liquid waste management system will generate a large quantity of records, not least from the monitoring, sampling and measurement requirements noted above.

Documents and records will be maintained in a secure and accessible form for an appropriate period of time such that they will be available to demonstrate the ongoing and historical safe management of liquid radioactive waste from arising to discharge. The site licensee will be responsible for putting in place a quality assurance, knowledge and document management system that ensures all relevant records generated during construction, commissioning and operation are available to support decommissioning waste management activities.

9. Gaseous Radioactive Waste Management Strategy

Gaseous radioactive waste is produced during the commissioning, operations, and decommissioning phases of the UK ABWR life. Commissioning of the UK ABWR unit will include commissioning of its gaseous waste management system and is therefore considered similar to the operations phase in this strategy document.

9.1 Operations

The systems in place for the management and treatment of gaseous radioactive discharges are described in PCSR Chapter 18: Radioactive Waste Management, sections 18.7 *Off-Gas System*, 18.8 *Heating Ventilation Ventilation and Air Conditioning System* and 18.9 *Tank Vent Treatment System*[Ref-7], PCSR Chapter 16: Auxiliary Systems, section 16.5 *Heating Ventilating and Air Conditioning System* [Ref-6] and are underpinned by Demonstration of BAT [Ref-8].

HF considerations have and will be incorporated in the design of each facility of the UK ABWR under the HF Integration Plan. Where human factors are relied upon as part of the BAT case, these instances will be fed into the HFI process outlined in PCSR Chapter 27: Human Factors [Ref-12].

The systems and equipment comprising the gaseous radioactive waste management systems are:

- The Off-Gas System (OG);
- HVAC systems for the following buildings and facilities:
    - Reactor Building
    - Turbine Building
    - Radwaste Building (including the Tank Vent Treatment System)
    - Service Building
- Main stack and associated plant and equipment.

9.1.1 The Off-Gas System

The design of the OG has been developed to address three primary functions:

1. To maintain the main Condenser vacuum by extracting non-condensable gas.
2. The safe recombination of flammable gases (hydrogen and oxygen), which are generated by radiolytic decomposition of reactor cooling water, to reduce the possibility of a hydrogen explosion.
3. To minimise and control the release of radioactive gases into the atmosphere by delaying and filtering the off-gas waste process stream to adequately decay short lived radioactive isotopes and filter out particulate matter.

The specification and performance of this system is addressed in detail within the PCSR Chapter 18 section 18.7 [Ref-7].

The main process equipment of the Off-Gas System includes the following:

- Steam Jet Air Ejectors (SJAEs)
- SJAE condenser
- preheater
- recombiners
- condenser
- cooler condenser
- activated charcoal adsorbers
- high efficiency particulate in air (HEPA) filter
- monitoring instrumentation, and
- process instrumentation and controls.

The main process plant and flow routes through the Off-Gas System are shown in Figure 9.1.1-1.

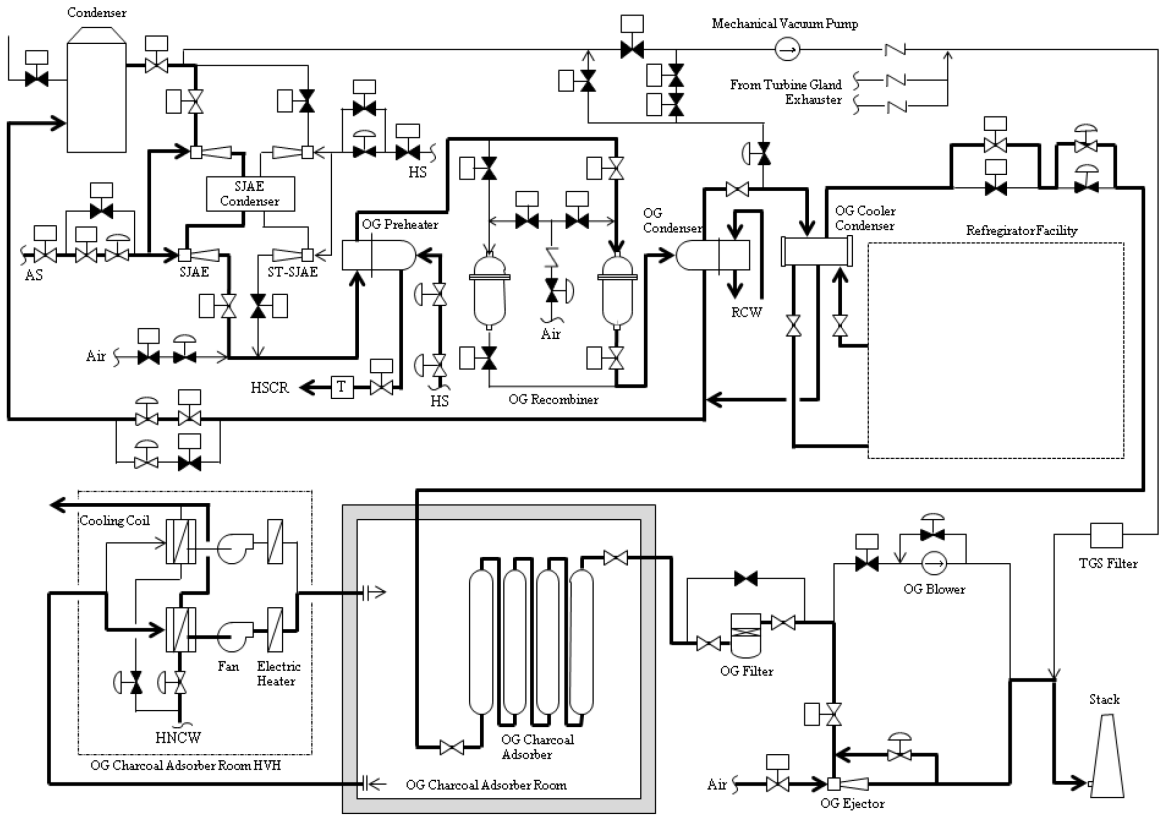


Figure 9.1.1-1: Schematic Drawing of the Off-Gas System

The Demonstration of BAT document [Ref-8] presents the following:

- 5.2.1. Argument 2a: Off-Gas Waste Treatment System
- 5.2.2. Argument 2b: Delay Beds for Noble Gases and Iodine

Radiation monitors are provided on each discharge line in the OG (OG Charcoal Adsorber discharge line, Gland Steam Exhauster and Mechanical Vacuum Pump discharge line) to monitor the release of the gaseous radioactivity.

Some of the radionuclides in the off-gas such as tritium and carbon-14 do not undergo treatment in the OG and are discharged directly to the environment via the main stack, however the majority of the tritium in the gaseous phase is removed from the off-gas by the OG recombiner and OG condenser. This is because the assessment of treatment techniques for these radionuclides has shown that the costs of installation and operation are very high and the reduction in impacts on members of the public and the environment is low. Installation of such equipment is therefore considered to be grossly disproportionate to any benefit that would be realised.

The charcoal adsorber delay beds provide adequate hold up times for the concerned radionuclides (noble gases and iodine) in the concentrations considered in the assessment.

The Off-Gas system will generate charcoal waste from the adsorption hold-up beds at the end of operational life (>60years). The charcoal will be treated as solid radioactive waste and is considered in Sections 10 and 11 of this RWMA document.

9.1.2 HVAC Systems

The functions of the HVAC system that are of relevance to the management of gaseous radioactive wastes are: limiting the leakage or spread of radioactive materials from plant and equipment in a room/area during operation or maintenance/inspection; confining such radioactive materials locally, and; where necessary, filtering contaminated air prior to its discharge to atmosphere.

The buildings identified with potential to generate gaseous radioactive effluent are the Reactor Building, the Turbine Building, the Radwaste Building, the Service Building and the solid waste treatment facilities. Where practicable, HVAC systems will discharge to the environment via the main stack. Exceptions will have their own HEPA filtered local discharge points.

In addition to the building HVAC system, the Radwaste Building includes a Tank Vent Treatment System as presented in PCSR Chapter 18, section 18.9 [Ref-7]. The Rw/B Tank Vent Treatment system is connected to the ullage space of the most active tanks within the Rw/B with the purpose of maintaining a depression, so that the air displaced due to effluent transfers is drawn into the Tank Vent Treatment system.

Example store designs are described in Section 11 of this RWMA document. The waste packages and overpacks anticipated for use in the stores are designed to be BAT by maintaining containment and, where practicable, incorporate passive cooling methodologies. The ILWS HVAC system will ensure an optimum storage environment. The SFIS and HLW store do not require HVAC systems.

Under section 5.2.4 “Argument 2d: Filtration of Airborne Particulate Matter” of the Demonstration of BAT [Ref-8], it is stated that the use of filtration technology within the UK ABWR HVAC system to abate particulate matter is considered ‘relevant good practice’ within the UK nuclear industry.

The HEPA filters from the HVAC systems are treated as solid LLW radioactive wastes and are considered in Sections 10 and 11.

9.1.3 Main Stack and Associated Plant and Equipment

The vast majority of the gaseous radioactive discharges from the UK ABWR are made via the main stack; this includes the residual gaseous wastes from the Off-Gas System and main building HVAC systems described in the previous sections. The HVAC and OG systems include HEPA filtration before discharge via the main stack located on the roof of the reactor building. Associated equipment includes the discharge monitoring equipment (9.3).

The Demonstration of BAT [Ref-8] presents, in section 5.5.1 “Argument 5a: Gaseous Discharge System - Main Stack”, arguments and evidence regarding the location of the stack, in relation to the single unit UK ABWR generic design.

9.2 Gaseous Radioactive Waste during Decommissioning

In agreement with the Generic PCSR Chapter 31: Decommissioning [Ref-11] and the Decommissioning Waste Management Topic Report [Ref-17], the gaseous radioactive waste management systems will continue in operation until such time as the areas they are serving are demonstrated not to require the removal of potentially radioactive gaseous waste. The following sections consider the gaseous radioactive waste management with reference to the decommissioning phases listed in section 8.3.

9.2.1 Phase 1: Before End of Generation (Pre-closure Preparatory Work)

Routine operation of the gaseous radioactive waste systems continues.

The radioactivity inventory of the systems will be evaluated. A safety and BAT assessment to consider the potential impact of decommissioning operations to workers, the public and the environment will be conducted. Regulatory submissions and applications for modified or new environmental permits will be prepared.

9.2.2 Phase 2: Immediately After End of Generation

The HVAC systems will remain operational. The construction and commissioning of a Hot Cell for the inspection of SF and packaging of stored SF/HAW includes a new HVAC system that will not discharge via the main stack.

9.2.2.1 Reactor Defueling

The OG system will continue operation following end of generation until conditions inside the condenser are stabilised and it is demonstrated that the system is redundant. This is estimated to be in the order of several days.

9.2.2.2 POCO

The redundant OG system will be dismantled and managed as VLLW and LLW as described in Sections 10 and 11 of this arrangements document.

Existing HVAC systems for radioactive areas will remain in operation to ensure the safety and environmental protection of the POCO operations. Where required local containment and filtration systems will be installed at the work place and connected to the existing HVAC system where practicable.

The removal of any HVAC system during POCO will be dependent upon demonstration that the area served has been declassified, will not require the HVAC system for future use and that there is no detrimental effect on other parts of the HVAC system.

9.2.2.3 Installation of a Decommissioning Waste Management Facility

The installation of a decommissioning waste management facility will require the installation of a new system. The BAT decision will be made by the future site operator with consideration of site specific constraints and opportunities.

9.2.2.4 System Decontamination

Existing HVAC systems will remain in operation to ensure the safety and environmental protection of the decontamination operations. Local containment and filtration systems will be installed at the work place where required.

9.2.3 Phase 3: Power Plant Decommissioning

9.2.3.1 Treatment of RIN and RPV

Following system decontamination, the RIN will be cut free and, where practicable, size reduced under water in the flooded RPV. The RIN items will be transferred to a pool for further size reduction (segmentation), characterisation, segregation, conditioning and packaging. Potential pool areas for use include the DSP and SFP, the preferred option being the DSP.

The underwater cutting of activated components will result in gaseous discharge. The characteristics of the gaseous discharge will depend upon the cutting technique used. For example, underwater plasma arc

cutting will produce more gaseous discharge than an underwater mechanical cutting technique. To manage the gaseous discharge, local containment and ventilation will be installed and connected to the HVAC system where practicable. Figure 9.2.3-1 below illustrates a possible containment and ventilation configuration during RIN cutting operations.

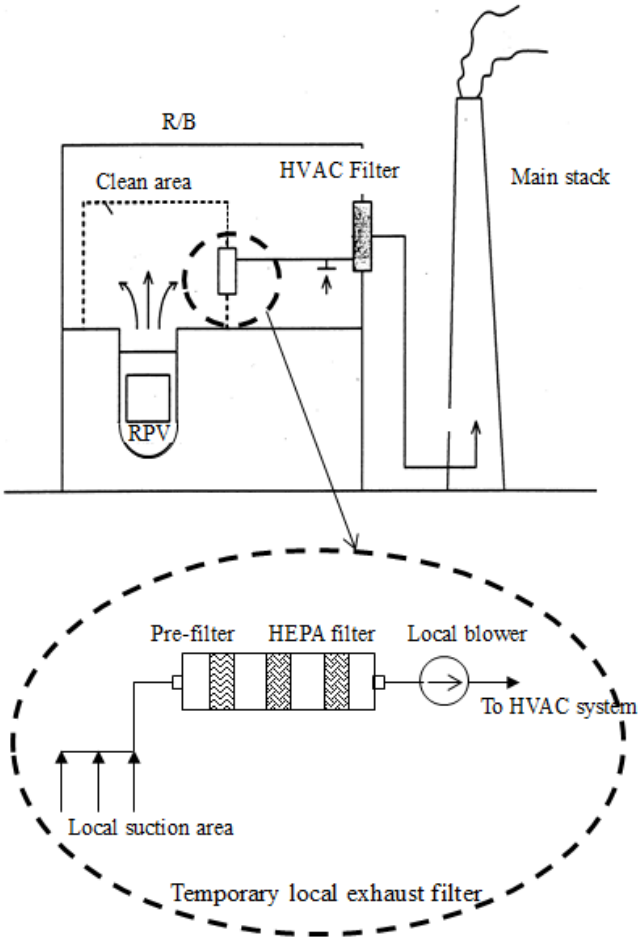


Figure 9.2.3-1: Example Containment and Ventilation System during Underwater Cutting in the RPV

The RPV will be segmented in air following the lowering of the retained water level in the RPV itself and the draining and decontamination of the DSP. Containment and ventilation arrangements in addition to those described for the RIN treatment are expected to include a fume extraction hood local to the RPV cutting tool, with the associated extraction and ventilation system sited on the operating floor level. A suitably contained and ventilated segmentation cubicle will be installed within the DSP to manage the gaseous discharge and airborne contamination hazard generated during size reduction cutting operations.

9.2.3.2 Continued Decommissioning Waste Management Facility Operations

Decontamination and size reduction of solid waste within the Decommissioning Waste Management Facilitywill be within installed local containment and ventilation systems as appropriate to the operations and materials to maintain operator safety and environmental protection.

9.2.3.3 HVAC System Dismantling

Once the HVAC system function is no longer required, the HVAC systems themselves will be decommissioned, decontaminated and dismantled in a manner that mitigates against potential radioactive contamination dispersal to the environment, using temporary mobile containment, ventilation and filtration equipment as required.

Secondary solid radioactive wastes will include HEPA filters and containment construction materials. The solid wastes will have similar characteristics to those produced during the site operations phase and will follow established waste treatment and disposal route as presented in Sections 10 and 11 of this arrangements document.

9.2.3.4 Building Demolition

Building demolition will be carried out once the radioactive inventory of the facility to be demolished has been removed or remediated. Radioactive gaseous waste management is not required.

9.2.4 Phases 4, 5, 6 & 7: ILW Storage, Emptying and Disposal, HLW and SF Interim Storage, Repackaging and Disposal

Hot Cell repackaging operations of HAW decay stored waste and SF prior to disposal will require a suitable HVAC system to manage the higher gaseous waste discharges during these operations. The HVAC system will be developed by the future operator during design of the repackaging facilities.

The HVAC systems serving the SWF, ILWS and the SF/HAW inspection and repackaging facility Hot Cell will be operational during, and beyond, the reactor decommissioning phase and will therefore be amongst the last site systems to be decommissioned. Pre-closure preparatory work (see Section 8.3) by the future operator will assess the specific requirements posed by these facilities.

No radioactive gaseous discharges are anticipated during phase 7: Demolition and Delicensing.

9.3 Monitoring, Sampling and Measurement

9.3.1 Sampling and Monitoring Locations

The sampling and monitoring locations are described in the Approach to Sampling and Monitoring document [Ref-18]. The Approach to Sampling and Monitoring document does not detail the precise sampling and monitoring equipment required as this needs to be BAT at the time of procurement. It does, however describe current methods and techniques that are deemed to be suitable.

9.3.1.1 In-process Sampling and Monitoring

The off-gas is continuously monitored before being fed to the main stack. Radiation monitors and grab sample points are installed at the inlet and outlet of the off-gas management system to continuously measure the gross radiation of the off-gas.

The HVAC exhausts are not continuously monitored before the junction to the main stack.

9.3.1.2 Discharge Monitoring

Radionuclides to be measured at discharge are listed in [Ref-18] and compared to EU commission recommendations.

The discharge from the main stack is monitored for gross radiation levels during normal plant operation as well as collection of particulate, iodine, tritium and carbon samples for laboratory analyses. A representative sample is continuously extracted from the main stack through an isokinetic probe, passed through the sampling equipment room for monitoring and sampling, and returned to the main stack.

9.4 Waste Record Management

Recording the operations and performance of the gaseous waste management system will generate a large quantity of records, not least from the monitoring, sampling and measurement requirements noted above.

Documents and records will be maintained in a secure and accessible form for an appropriate period of time such that they will be available to demonstrate the ongoing and historical safe management of gaseous radioactive waste from arising to discharge. The future site licensee will be responsible for putting in place a quality assurance, knowledge and document management system that ensures all relevant records generated during construction, commissioning and operation are available to support decommissioning waste management activities.

10. Management of the Solid Radioactive Waste Streams

10.1 Waste Category

In the UK, radioactive wastes are classified in terms of the nature and quantity of radioactivity that they contain and their heat-generating capacity [Ref-19], as follows:

- VLLW is a subset of LLW and there is also a category of exempt waste which does not require an authorisation for disposal.
- LLW are wastes having a radioactive content not exceeding 4 GBq per tonne of alpha activity, or 12 GBq per tonne of beta/gamma activity.
- ILW are wastes exceeding the upper boundaries for LLW, but which do not require heat generation to be taken into account in the design of storage or disposal facilities.
- HLW are wastes in which the temperature of the waste may rise significantly as a result of radioactivity (i.e. decay heat), so this factor has to be taken into account in the design of storage or disposal facilities. SF is heat generating and requires similar management.

HAW comprises all HLW and ILW, and a small fraction of LLW with concentrations of specific radionuclides that prohibit disposal at existing and planned future disposal facilities for LLW.

10.2 UK ABWR Waste Streams

The radioactive wastes and SF that Hitachi-GE expects the UK ABWR to generate arise from the systems shown in Figure 10.2-1: Outline of Radioactive Waste Management System. They are grouped in 10.2-1 into 14 waste streams and one SF stream and include all operational, maintenance and decommissioning waste. The referenced Figure and Table also indicate the different waste types grouped as ‘Process Waste’, ‘Decommissioning Waste’ and ‘Miscellaneous Waste’. The quantities of these wastes have been minimised as described in Claim 3 and the supporting Arguments of the Demonstration of BAT [Ref-8]. They are described in more detail in Appendix A of this report. Each waste type is described in 10.4.

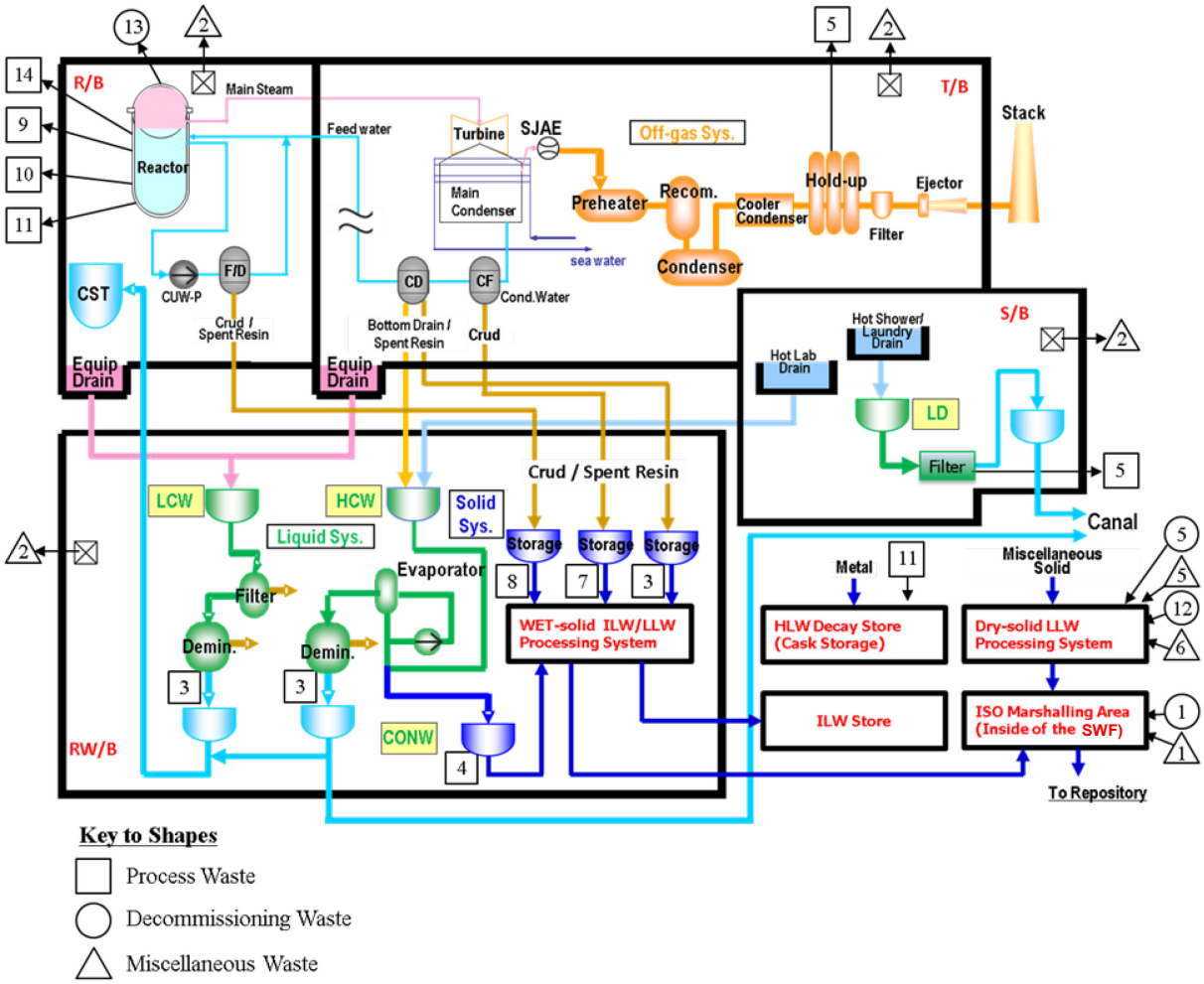


Figure 10.2-1: Outline of Radioactive Waste Management System

Note: The Acronyms used in the above figure are as listed in Section 1 above.

The numbers used identify the waste arising and are given in the left hand column of Table 10.2-1.

Table 10.2-1: Summary of Waste and Spent Fuel Streams

No.	Title	Description	Category	Form	Arising during
1	Dry active waste	Miscellaneous dry, low activity wastes in various forms; including metals, concrete cloths, paper, etc.	VLLW	Solid	Operations & Decommissioning
2	HVAC Filters	Arising from filter changing in air treatment facilities from exhausts from Reactor (R/B), Turbine (T/B), Radwaste (Rw/B) and	LLW	Solid	Operations & Decommissioning

No.	Title	Description	Category	Form	Arising during
		Service (S/B) Buildings as well as waste treatment facilities.			
3	Bead resin	Arising from the CD, LCW and HCW demineralisers; Styrene divinylbenzene copolymer matrix.	LLW (identified as borderline waste, see 10.4.6)	Wet	Operations & Decommissioning
4	Concentrates	Arising from the HCW/CONW evaporators comprises particulate and dissolved species.	LLW	Wet	Operations
5	Miscellaneous combustible	Includes plastic sheets, paper, wood, cloth, oil and activated carbon from Laundry Drain (LD) and Off-Gas systems.	LLW	Solid	Operations & Decommissioning
6	Miscellaneous non-combustible	Spent hollow fibre filters, metal, pipes, cables, lagging, gas filters, concrete and glass.	LLW	Solid	Operations & Decommissioning
7	Sludge (crud)	Arising from backwashing of various filters from the CF and the LCW systems	ILW	Wet	Operations
8	Powder resin	Arising from the CUW and FPC filter demineralisers; cross linked polystyrene matrix. Contains particulate corrosion product.	ILW	Wet	Operations & Decommissioning
	Ion exchange resin	Secondary waste arising from system decontamination of RPV, RIN and closed loop systems.	ILW	Wet	Decommissioning
9	Higher activity metals – control rods	Cruciform shape metallic construction containing stainless	HAW (HLW at arising, ILW	Solid	Operations & Decommissioning

No.	Title	Description	Category	Form	Arising during
		steel tubes in each wing of the cruciform filled with boron carbide powder. Hafnium may also be employed to perform the same function of reactivity control.	at disposal)		
10	Higher activity metals – Fuel Channels	Zircaloy box which surrounds the fuel bundle. Approx. 4.3m long and 15 × 15cm square.	HAW (Remain with fuel assemblies)	Solid	Operations
11	Higher activity metals - others	Various reactor core components including from SRNM and LPRM systems.	HAW (HLW at arising, ILW at disposal)	Solid	Operations
12	Contaminated and irradiated metal and concrete	Non-combustible, largely metal and concrete items. Some very large and requiring size reduction. Including SFP furniture (e.g. fuel racks)	LLW	Solid	Decommissioning
13	Contaminated and irradiated metal	Metal items. Some very large and requiring size reduction. (e.g. RIN & RPV segments)	ILW	Solid	Decommissioning
14	Irradiated metal	Reactor core components and from areas subject to activation. (e.g. RIN & RPV segments)	HAW (HLW at arising, ILW at disposal)	Solid	Decommissioning
15	Spent Fuel	Used fuel assemblies	HLW	Solid	Operations

Table 10.2-1 identifies the SF as the only items to demonstrate heat generation beyond ILW at the time of disposal. Core components that generate heat immediately after they have been removed from the core environment and are therefore HLW at arising will, after an appropriate decay time, demonstrate heat generation below the upper limit specified by RWM for disposable ILW packages [Ref-20].

10.3 Waste Management Stages

Following its generation, radioactive waste will undergo a number of management stages, before it is finally disposed. Joint guidance from the HSE, Environment Agency and Scottish Environment Protection Agency identifies six stages [Ref-19]: pre-treatment, treatment, conditioning, storage, retrieval and disposal. The Regulators note that implementation depends on the type of waste and the strategy selected for its management.

10.3.1 Waste Segregation

Waste segregation is an essential aspect of the waste management system to ensure that waste is assigned consistently and appropriately to onward management, treatment and disposal steps, demonstrating compliance with the principle of the waste hierarchy.

Waste segregation will be carried out as close to source as is practicable. Figure 10.3.1-1 below has been copied from the solid waste monitoring requirements document [Ref-10] to illustrate how effective identification and segregation of waste may be applied, including how reference to design history is relevant. The example is taken from the flowsheet illustrating the monitoring requirements for dry-solid LLW.

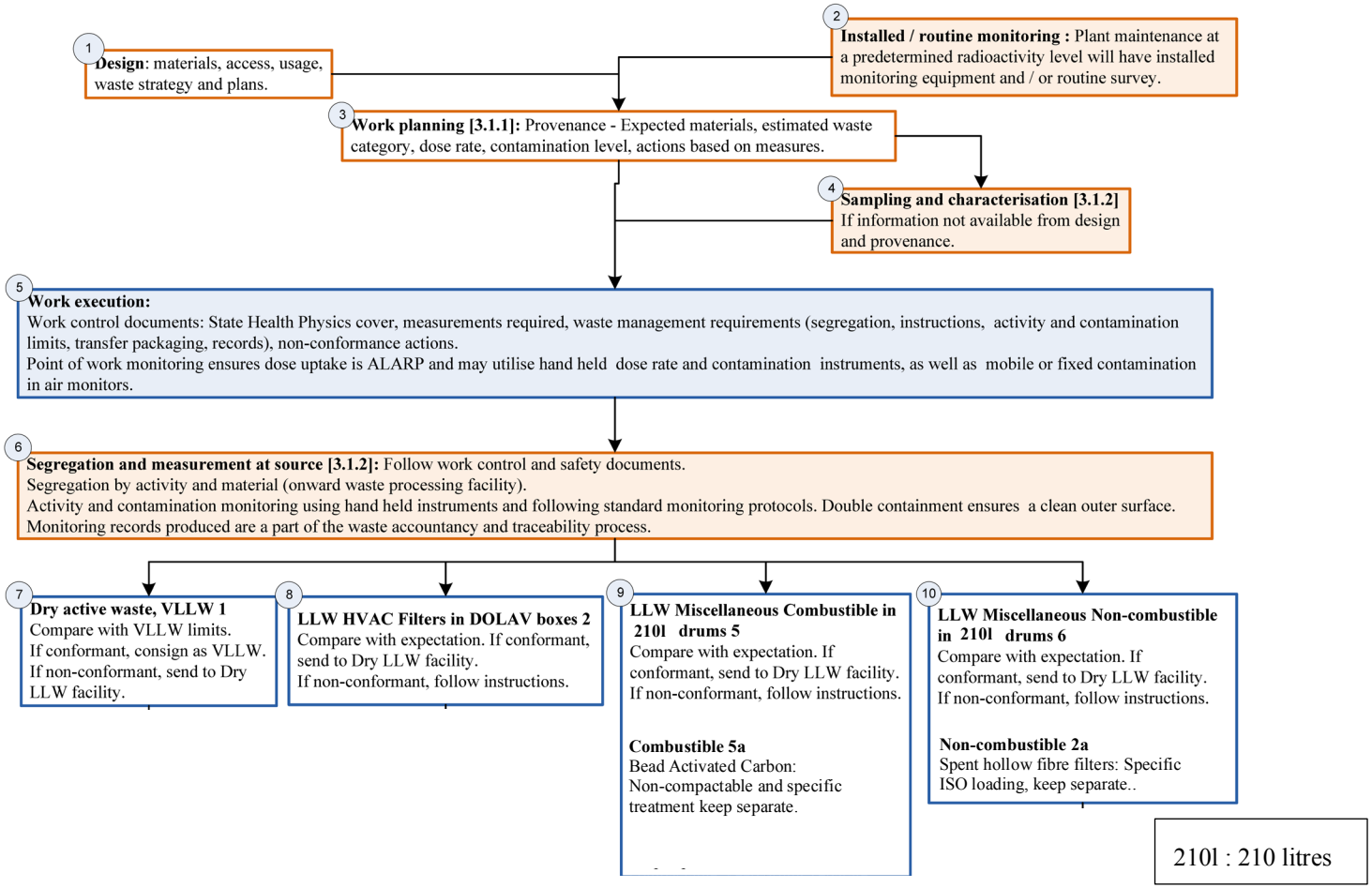


Figure 10.3.1-1: Example of a Process Leading to Waste Segregation at Source (Dry-solid LLW)

The monitoring requirements document also presents and describes the requirements for wet-solid LLW, wet-solid ILW and dry-solid ILW and is summarised in Appendix B of this arrangements document.

10.3.2 The Waste Management Stages

For managing the waste streams from UK ABWR, the following stages will be used:

- **Segregation of waste** – Waste will be segregated as close to source as is practicable such that simple and stable waste (rather than complex and unstable) forms is preferred, appropriate (BAT) waste treatment and disposal routes are followed, the safety case of onward facilities is not challenged and the radiological dose uptake of operators is maintained ALARA.
- **Short term temporary buffer storage** – segregated waste may be temporarily stored, for example, in a buffer tank in order to accumulate an adequate batch size for treatment. At this stage or during subsequent treatment stages the waste stream will be characterised to determine its physical, chemical and radionuclide properties. Characterisation methods will include the use of sampling and analysis (typically for wet wastes) and radiological assay (typically for solid wastes). The identification of potential sampling, measurement and monitoring points in the process, as well as proposed requirements and techniques are described in the Radioactive Solid Wastes Monitoring Requirements document [Ref-10].
- **Treatment** – involves changing the characteristics of the waste by processes such as volume reduction (using drying, cutting, compaction or incineration), cleaning/decontamination by filtration or ion exchange, or precipitation.
- **Conditioning for Interim Storage** - involves transforming the waste into a form that is suitable for handling, transfer, storage and, potentially, disposal. This might involve immobilisation of the waste and placing it into steel drums or other engineered containers to create a waste package. In the case of VLLW, LLW and ILW, such a package should be suitable for disposal but for SF and HLW such as control rods re-packaging will be needed at the end of interim storage and before disposal.
- **Transfer to Interim Store** – movement of the package, within a shielded cask if necessary, from the packaging facility to the on-site interim store.
- **Interim Storage** – on-site interim storage will be necessary for ILW and SF until the planned GDF is available to receive the waste. Some wastes may need to be stored in a passively safe condition for many decades. In the case of LLW, temporary storage of packaged waste may be required in order to accommodate the requirements of the transport system and the receipt arrangements at a disposal site (e.g. LLWR). Storage facilities will ensure that waste is retrievable for inspection and disposal.
- **Packaging for Disposal** –SF (and HLW at arising) will need re-packaging after interim storage into a container approved for disposal.
- **Transport for Disposal** – movement of the packaged waste and SF, within suitably shielded and protected flasks or containers, from the reactor site to the GDF (for SF and ILW), and to a suitably permitted disposal site for VLLW and LLW (e.g. LLWR).
- **Disposal** - packages of radioactive waste are deposited in an off-site disposal facility with no intention of retrieval.

10.3.3 Waste Record Management

Adequate records will need to be kept during the whole management cycle. In particular RWM require that records are kept to ensure that the history of the wastes and specific package properties are preserved to inform their disposability and that their long term evolving properties will remain within acceptable limits.

Documents and records will be maintained in a secure and accessible form for an appropriate period of time such that it will be available for the safe management of radioactive waste from arising to disposal. The site licensee will be responsible for putting in place a knowledge and document management system that ensures all relevant records generated during construction, commissioning and operation are available to support decommissioning waste management activities.

10.3.4 Characterisation

Characterisation through sampling, measurement, monitoring and calculation will be carried out as appropriate to support all stages of the waste management process [Ref-10]. Characterisation to adequately define the waste and ensure effective processing will be carried out as early in the waste management process as practicable by, for example, examination of the waste provenance (material and history) or sampling and analysis.

Characterisation sampling, measurement and monitoring information will be maintained within the site knowledge and document management system identified in 10.3.3.

10.4 Wastes Arising

For all VLLW and LLW streams, “Agreements in Principle” as discussed in the Demonstration of BAT Argument 4c [Ref-8] have been obtained to demonstrate that the wastes can be managed and, where appropriate, disposed of in the UK. For the ILW and SF streams a disposability assessment has been carried out by RWM as discussed in the Demonstration of BAT Argument 4d [Ref-8] to confirm acceptability of these, when suitably packaged and subject to detailed LoC assessments, into a future GDF. The agreement in principle and the disposability assessments are discussed further in Section 13 Disposability.

The following sections describe each category of waste envisaged to arise from a UK ABWR and the options identified during GDA for its packaging, interim storage and disposal. These options are based upon good practice as applied to similar wastes on UK legacy sites which would be considered as BAT at this time. However, in developing their plans for packaging, interim storage and disposal, the selection of the appropriate option by the future site operator will also be subject to the application of BAT within their own decision making process.

10.4.1 Very Low Level Waste

VLLW is a subset of LLW and falls into two distinct categories:

- Low Volume VLLW (conditionally exempt <200 MBq per annum) - wastes that can be safely disposed of to an unspecified destination with municipal, commercial or industrial waste, each 0.1 cubic metre of material containing less than 400 kBq of total activity, or single items containing less than 40 kBq of total activity. There are additional limits for carbon (C-14) and tritium (H-3) in wastes containing these radionuclides. Only applicable to non-nuclear industry.
- High Volume VLLW (bulk disposals) – wastes with maximum concentrations of 4 MBq per tonne of total activity or 40 MBq per tonne for tritium total activity that can be disposed to specified landfill sites. There is an additional limit for tritium (40 MBq/t) in wastes containing this radionuclide [Ref-21]

After the waste is removed from its site of origin, it will be subject to controls on its disposal, which will be specified by the environmental regulators.

For a nuclear power station the low volume VLLW sub-category is not relevant and therefore only high volume 'bulk disposals' are considered in this document. This is because the Environment Agency does not allow disposal of low volume VLLW originating from a nuclear site via this route.

VLLW will be dealt with according to current UK practices, [Ref-22] and subject to, for example, the VLLW acceptance criteria for the LLWR, [Ref-21]. The main criteria are as noted above with specific restrictions being determined through for example, the Waste Enquiry Process, as determined by the LLWR.

Only one VLLW stream has been identified for UK ABWR, specifically, Dry Active Waste. This is mixed waste that will arise during reactor operations and decommissioning. The waste consists of contaminated personal protection equipment, monitoring swabs, plastic, equipment, structures and contaminated plant. These different forms of dry active VLLW will require specific removal, handling, sorting and size reduction techniques depending on their physical form and characteristics prior to treatment.

Non-aqueous liquid and non-aqueous liquid contaminated waste may be considered as a sub-set of this VLLW stream and is discussed in its own right in Section 10.6.2.

10.4.2 Low Level Waste

LLW is defined as waste with a radioactive content not exceeding 4 GBq per tonne of alpha, or 12 GBq per tonne of beta/gamma activity.

Most LLW in the UK arises from the operation of nuclear power stations and nuclear fuel reprocessing facilities, as well as the decommissioning and clean-up of nuclear sites. Operational LLW is principally lightly contaminated miscellaneous waste, arising from maintenance and monitoring, such as plastic, paper and metal. LLW from decommissioning also typically includes building materials and metal plant and equipment.

Most LLW from nuclear licensed sites is currently managed via LLWR Ltd., which provides a service for the range of wastes produced.

For waste generators that use LLWR Ltd, the LLW is dealt with in accordance with the strategy to manage waste through an LLW Joint Waste Management Plan, which is agreed between the waste producing site and LLWR Ltd. This organisation encourages an approach based upon the Waste Hierarchy and a number of recycling options are offered for waste producers to use. Where solid wastes are produced these can be disposed of to the LLWR, in accordance with their published acceptance criteria [Ref-23]. This 'complete' and currently available service offered by LLWR Ltd. to waste producers is used in this GDA strategy document as an example and reference LLW disposal service. Any future site operator will have to choose their own arrangements based on the site specific requirements (e.g. site location) and the requirement to demonstrate selection of the optimal disposal route at that time. The reference, example service from LLWR Ltd. comprises four main options, which are detailed in [Ref-24] and briefly described below:

a. Metallic Waste Treatment Service

This service is a recycling option. Waste can be treated by decontamination, blasting or melting to remove the radioactive content. The vast majority of the metal can then be recycled as exempt or out of scope waste thus reducing the overall volume needing disposal. Any process secondary waste material is either consigned to the LLWR for disposal as LLW or VLLW, depending upon its radioactivity, or disposed of by

the Service Supplier, depending upon contract arrangements between the waste producer, LLWR Ltd. and the Service Supplier.

b. Combustible Waste Treatment Service

This service is a volume reduction option. Waste can be incinerated to reduce its volume. The remaining secondary waste, i.e. ash and other solid waste from the incinerator, is either disposed of by the Service Supplier or consigned to the Low Level Waste Repository for disposal as either LLW or VLLW, depending upon waste characteristics and the contractual arrangements as noted above.

c. Super-compactable Waste Treatment Service

This service is a volume reduction option. Waste can be treated by shredding and / or high force compaction to reduce its volume. The secondary waste product is consigned to the LLWR for disposal.

d. Low Level Waste Disposal Service

This service is a disposal option. Waste that is not suitable or selected for treatment, has already been treated or is secondary waste from a treatment process is consigned to the LLWR for disposal. LLWR Ltd. offers a range of standard disposal containers which are mostly centred on the use of the half height International Organisation for Standardisation (ISO) container. The containers can be filled with waste in various forms, compliant with the applicable waste acceptance criteria, either at the waste producer's site or at the repository. For the containers consigned from the waste producer, after transport to the repository the interspaces within the ISO container are filled with a cement grout prior to emplacement in the repository.

A site operator will need to make business decisions, which will also include commercial and logistical requirements which may indicate that there are other ways of dealing with specific wastes. For example, the site operator may decide to contract directly with a waste service supplier rather than utilising the LLWR contract arrangements. These decisions will be made by the site operator with appropriate consideration of site-specific influences (e.g. proximity principle) and the application of BAT.

Six distinct LLW streams have been identified as arising during operations only and some additionally during decommissioning. They are described briefly below together with the options available for treatment, packaging and disposal as identified. The UK practice generally is to consign packaged LLW to the LLWR via the Joint Waste Management Plan, as noted above. Significant on site storage facilities are not necessary but a facility for buffer storage, likely to be for approximately 2 years' worth of LLW arisings, will be provided to allow flexibility to manage consignments without adversely affecting generation rates, which could otherwise cause bottlenecks. For each LLW stream, after accumulation of a number of drums of packaged waste in the buffer store they will be consigned to the LLWR in accordance with the Joint Waste Management Plan.

For ion exchange resins, incineration has been used for some sites in Japan however this approach is not being developed for the UK ABWR GDA submission because analysis of the ion exchange resins radioactivity content has shown that the levels and package dose rates are too high to be acceptable under the applicable WAC for incineration via the LLWR [Ref-25] [Ref-26] [Ref-27] which is considered here as representative of incineration service providers .

The following Sections briefly describe each stream.

i. HVAC Filters

HVAC filters are installed in the exhaust outlets of various buildings, as described in the PCSR and listed in Table 10.2-1 and include High Efficiency Particulate Air (HEPA) filters. The detailed type and construction of these filters will depend upon the operational and safety case requirements.

The design and application of filters for the UK ABWR will follow UK best practice for both performance/safety requirements and design/construction. The filters can be supplied in a range of shapes, sizes and materials, mostly with glass fibre media.

ii. Bead Resin

Bead resins are used within demineraliser beds to remove soluble radioactive species from various water circuits from the Condensate Demineraliser (CD), Low Chemical impurities Waste (LCW) and High Chemical impurities Waste (HCW) systems as described in PCSR Chapter 18 Radioactive Waste Management, sections 18.5 and 18.6 [Ref-7]. The precise resins used by any UK site operator will be determined by the operator themselves; however the GDA submission assumes the use of resins used in the Japanese ABWR systems comprising a styrene divinylbenzene copolymer matrix. When the resins are spent, Japanese practice is to discharge the beds to buffer storage tanks in order to implement efficient periodic packaging campaigns. Treatment and conditioning includes on-site incineration and packaging the resultant ash in drums for suitably low specific activity resins or direct cementation in drums if the specific activity is considered too high for incineration.

Historically, UK nuclear power stations have stored their spent resins under water in storage tanks for a period of time before applying a solidification process and direct disposal to the LLWR.

iii. Concentrates

The Concentrated Waste (CONW) tanks hold wastes arising from the HCW evaporators as described in PCSR Chapter 18 Radioactive Waste Management, sections 18.5 and 18.6 [Ref-7]. These wastes have a high impurity due to particulate and dissolved species that they are not suitable for demineralisation. The contributory HCW streams arise from sources such as Rw/B sumps, S/B sumps, CD drains and laboratory.

Japanese practice for these wastes is to solidify with a suitable cement formulation in disposal drums, typically 200 litre, before consignment to a suitable disposal facility.

iv. Miscellaneous Combustible

Miscellaneous combustible wastes are generated through routine operations, maintenance and decommissioning in radioactive areas. The waste consists mainly of contaminated personal protective equipment, polyethylene (sheet, bag), paper, wood, cloth, rubber gloves, turbine oil waste and spent active carbon filter media.

Non-aqueous liquid (e.g. oil and liquid scintillant cocktail) and non-aqueous liquid contaminated wastes are considered more specifically in section 10.6.

The typical Japanese strategy for miscellaneous combustible wastes is incineration.

If combustible waste demonstrates characteristics that do not conform to the acceptance criteria of the available incineration facilities, the waste will be assessed on a case by case basis and managed according to a demonstrably BAT non-combustible disposal strategy.

v. Miscellaneous Non-combustible

Non-combustible wastes are generated through routine operation, maintenance and decommissioning in radioactive areas comprising such materials as CF and LCW spent hollow fibre filter membrane, metals, concrete, lagging, glass etc. During decommissioning, the metals category will consist mainly of removed plant items and is included as a separate category below. These wastes may include some items which could be dealt with in ways other than direct disposal and the requirements of the Waste Hierarchy will be applied.

It is assumed that solid sealed sources used for monitoring instrument daily checks and calibrations will be returned to their supplier for re-use, recycling or disposal. In the event that this is not

possible they will be treated as a low volume, low radioactive non-combustible waste form. The routine primary calibration of instruments will be sub-contracted to a suitable supplier who will have responsibility for management and disposal of their own calibration sources.

vi. Contaminated and Irradiated Metal and Concrete (Decommissioning)

Contaminated and irradiated metal and concrete wastes generated during the decommissioning phase will comprise large volumes of metal and concrete items. Many will be very large and require size reduction. Segregation of waste based upon composition, radioactivity and contamination will be required and appropriate treatment and disposal strategies applied. The strategy for management of these wastes is described in PCSR Chapter 31 Decommissioning [Ref-11] and the Topic Report on Decommissioning Waste Management [Ref-17]. However, the means of dealing with these wastes arising in the LLW category will be consistent with the waste hierarchy and (for example) the Joint Waste Management Plans developed with LLWR Ltd. Where practicable waste will be re-used or recycled.

10.4.3 Conditioning Option Descriptions: Very and Low Level Waste

The VLLW and LLW conditioning options presented in this section have been considered in the GDA process. Subsequent optioneering assessments have been carried out to select preferred options (Section 10.8) and conceptual design studies of waste management facilities capable of delivering the preferred waste treatment and disposal options have been produced (Sections 11.1 and 11.2).

For VLLW and LLW the use of the LLWR is assumed as an example. Other suitably licenced and permitted treatment and disposal suppliers are available, however for GDA, where a specific site location is not assumed, the use of LLWR Ltd. as a generic reference supplier is considered appropriate.

The conditioning options are presented in Figure 10.4.3-1 below with additional details given in the accompanying notes.

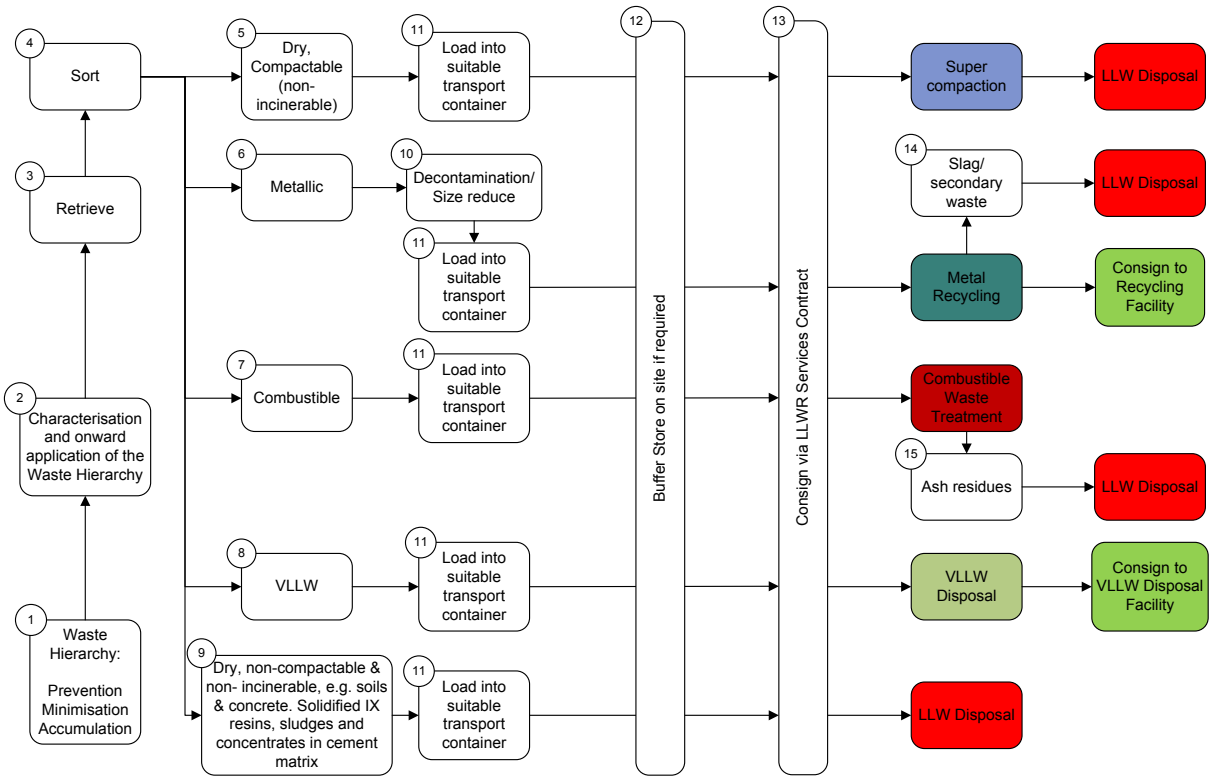


Figure 10.4.3-1: VLLW and LLW Conditioning Options

Notes for Figure 10.4.3-1: VLLW and LLW conditioning options

1. The waste hierarchy will be applied to design and operation to minimise the volumes of waste accumulated. Expected waste characteristics and rate of arising are estimated in advance based upon plant design and operation. The wastes are accumulated in suitable controlled facilities in accordance with current UK practice to ensure adequate containment and control of the materials and that subsequent retrieval for onward processing and disposal can be undertaken in accordance with BAT principles and regulatory expectations.
2. All wastes are managed in accordance with the Waste Hierarchy to ensure that final waste volumes are minimised. The characterisation data are sufficient to ensure that each waste item is dealt with in an optimal manner according to its category and to enable the provision of adequate data for the applicable waste route; for example to enable adequate justification for compliance with the applicable Waste Acceptance Criteria (e.g.) of the LLWR.
3. The waste items are retrieved from their accumulation facilities using appropriate standard UK practices. Solid waste items can be retrieved using tools and grabs in facilities which would mostly be manually operated and able to ensure adequate protection to an operator from direct radiation dose or contamination. Retrieval is into a sorting facility or directly into a suitable container, depending upon the waste item, for subsequent treatment.
4. Where waste items are mixed, a facility for sorting the waste enables the streams to be segregated and directed to the most appropriate process for subsequent treatment in accordance with the Waste Hierarchy.
5. Dry, compactable (unsuitable for incineration) wastes include heterogeneous items such as those which arise during maintenance operations within the nuclear island. Comprising metal plate, pipes,

cables, lagging material, gas filters, concrete and glass. HVAC filters may also be included in this category.

6. Metallic wastes may arise from the above stream and are segregated during the sorting process
7. Combustible wastes comprise dry active waste generated through routine and maintenance operations. The waste may consist of polythene (sheet and bag), paper, wood, cloth (wipes and gloves), rubber gloves and spent active carbon.
8. VLLW items arise from operations and maintenance and include such items as low activity piping, motors and heat insulators from maintenance activities
9. Dry, non-compactable & unsuitable for incineration wastes include such items as soils & concrete and other similar items which are segregated from other wastes, as described above. This category also includes the wet LLW streams which arise, such as ion exchange resins, sludge and concentrates which are rendered as dry and non-compactible, typically by mixing with a suitable solidification medium (e.g. a cement powder formulation) in an appropriate disposal container such as a Third Height ISO container (THISO) or 210 litre drum. Drained hollow fibre filters that may contain residual moisture may also be encapsulated in a matrix such as cement to produce dry solid LLW. There are a number of existing wastes from UK legacy sites which have previously been solidified in this manner and hence a suitable formulation can be based upon these.
10. Where applicable to specific waste streams, decontamination and size reduction is undertaken. This step is applicable where metals are prepared for subsequent melting and recycling or where other items (e.g. concrete) may be decontaminated to allow for the bulk of the waste to be recycled as aggregate or to be disposed of to a permitted landfill site rather than to the LLWR. Size reduction may also be necessary solely to ensure that the waste items can be suitable for packaging in a standard container such as a 210 litre drum.
11. When the waste is in a suitable form (e.g. via solidification of wet wastes, size reduction etc.) they are loaded into a suitable transport container. This may be the standard half height ISO container, which is specified by and used at the LLWR. In this case, after transport to the LLWR, the container is infiltrated with a cement grout and allowed to cure prior to emplacement within the LLWR vault. LLWR also specifies a number of other standard containers which may be used for transport of wastes for subsequent treatment at the LLWR or at one of its suppliers where other processes are applicable for treatment of the waste; for example super compaction or incineration.
12. The transport containers are managed in an on-site buffer store whilst awaiting consignment to an off-site treatment and / or disposal facility. This may be required to comply with the Joint Waste Management Plan, agreed between the site operator and LLWR which would include a schedule of waste deliveries to LLWR for onward processing or direct disposal, depending upon the waste type.
13. It is assumed for the GDA submission that all VLLW and LLW are consigned via a LLWR Services Contract and utilise the well-established facilities available for dealing with the wide range of wastes specified. This ensures that the Waste Hierarchy is adequately applied in directing wastes for treatment via the most appropriate route to ensure that the quantities of waste consigned for disposal in the LLWR vaults is minimised. Hence, the inputs from the buffer storage area are dealt with in a manner appropriate to the waste, which could be any one of the 5 outputs shown.
14. Slag secondary waste residues which arise from metal recycling are treated according to their characteristics. Their radionuclide content is carefully determined to ensure that the ‘concentration’ effect from the melting process has not rendered this waste as ILW (in the event that it has, the residues are treated as ILW and processing will follow the appropriate route). Typically, these LLW residues may be packaged in a similar manner to wet wastes as identified above for ion exchange resins, sludge and concentrates. In this case the residues may either be mixed with a prepared cement grout in a mixing drum or by mixing the residues with water and adding a suitable cement blend

within a mixing drum, typically 210 litre. A process and formulation for solidification of ash and dusts has previously been developed for UK legacy sites and hence these secondary wastes will be dealt with using a similar process.

15. The ash residues arising from the incineration process can also be dealt with in a similar manner to the above noted for the slag secondary residues. Typically, hazardous waste incinerator operators plan and manage the burning of radioactive waste such that the resultant ash is disposable via their permitted disposal routes. Compliance with the relevant facility's acceptance criteria enables this effective management.

10.4.4 Intermediate Level Waste

ILW has radioactivity levels that are higher than LLW but which do not generate enough heat to require special storage or disposal facilities. However, like other radioactive waste, it needs to be contained to protect workers, the public and the environment from the radiation and contamination. ILW includes metal items such as fuel cladding and redundant reactor components, and sludge and resins from the treatment of radioactive liquid effluents. The main waste types are described below:

- Sludge, also referred to as "crud", arising from filtration of water streams.
- Powder ion exchange resins, arising from water treatment filter/demineralisers. This stream also contains some sludge.
- Activated metals arising from locations within the reactor which are subjected to irradiation. Although potentially HLW at arising, the activated metals are expected to be ILW at disposal due to radioactive decay and cooling during the period between arising and disposal to the GDF. They are therefore considered here as ILW when considering potential disposal options.

Several viable options exist to manage ILW over the longer term in the UK. As noted previously, a site operator will make the final decision as to how they intend to manage their wastes; however, for GDA, all the viable options for ILW have been initially described. In order to demonstrate that the waste produced by the UK ABWR can be disposed of and managed in the UK regulatory system a single ILW management option has been selected to enable more detailed studies and analysis. At this stage the option of cement encapsulation (for solid items) and solidification (for wet/slurry wastes) into unshielded stainless steel containers has been selected as the packaging method to be adopted for a disposability assessment by RWM.

The ILW will be dealt with according to the requirements of RWM and will be subject to disposability assessments during the GDA process (see section 13). Following GDA, site-specific waste streams and packaging methods will be assessed via the LoC process to obtain endorsement. Again, the adoption of the stated option for GDA will not preclude a future operator from selecting another method, subject to completion of relevant optioneering and BAT assessments, business case analysis and LoC assessments.

The physical, chemical and radionuclide properties of the wastes will be assessed by RWM to determine compatibility with the current GDF concept. This process has been developed for the arising of legacy wastes from the currently operating and decommissioning sites and it is envisaged will be applicable to wastes arising from the UK ABWR, when site-specific information is available.

The management of ILW streams generated from operating a UK ABWR site are likely to fall within a number of currently applied processes, as discussed in the following sections.

10.4.4.1 General Packaging Options

There are currently a range of different containers and associated packaging processes which could be used

for packaging these wastes in the UK. They fall into two broad categories:

i. Thin walled containers

These containers are usually manufactured from stainless steel within which a wasteform is produced, either by addition of an immobilisation matrix or by intimate mixing of the waste (if it is water based slurry) with a suitable cement based formulation. For these containers there would be a need for a shielded onsite store to shield against direct dose arising from the packages. The combination of container and wasteform produce a package which complies with the specification requirements of RWM [Ref-28] to ensure durability and predictable evolution over the periods of on-site interim storage and eventual transport to and disposal in the GDF. Alternative immobilisation matrices are also available for specific wastes; for example certain polymers have been used for specific, 'niche' or unusual wastes. For transport, these packages are overpacked in a shielded transport container to protect the public from radiation dose, (in compliance with the relevant transport regulations) and the package from the requirements of the hypothetical accident requirements (as defined within those regulations).

ii. Robust shielded waste containers

In these containers the waste contents have been subject to simpler processes, such as size reduction and drying, without the introduction of an immobilising matrix. The requirements for such a package for interim storage, transport and disposal to a GDF are largely met by the container alone with little credit being claimed for the wasteform inside. These containers alone would also provide sufficient external shielding and integrity to comply with the relevant transport regulations, depending upon the properties of the radioactive contents. It is also envisaged that interim stores for these packages would be much simpler, and hence cheaper, than for the thin walled containers, as they would need only to be weather proof and secure, albeit for long periods. The document [Ref-29] provides a description of how such packages could meet the requirements of the RWM specification requirements noted above.

For the purposes of GDA, either package would be considered viable, subject to a satisfactory disposability assessment by RWM. A number of LoCs for packages comprising stainless steel containers and cemented wasteforms have been issued by RWM for a range of wastes which are directly analogous to the ILW streams arising from the UK ABWR. Consequently, adoption of this approach is based upon well recognised and informed approaches. RWM have also assessed two submissions for conceptual LoCs using robust shielded containers [Ref-30] and [Ref-31]. The assessments show that this type of package can be made disposable provided certain specific underpinning information is submitted as summarised below:

a. Substantiate the performance of the packages under the accident scenarios for GDF operations, either demonstration of complete containment or provide refined Release Fraction values;
b. Understand the constraints on the water content of the waste and any associated risks due to pressurisation of the containers;
c. Provide confidence that the functionality of the lid bolts can be maintained during storage prior to transport, allowing the seals to be changed as necessary; and
d. Demonstrate that the requirements for Data Recording and Management Systems are understood.

Where wastes are packaged during the operational period they would then be stored on site in an ILW store, pending the availability of a GDF. The store type (shielded or unshielded) would be determined in conjunction with the choice of waste packaging option; whether the waste packages are unshielded or self-shielded as noted in options i & ii above. Until a waste container is selected for the UK ABWR – the on-site interim storage requirements are unknown. The Nuclear Decommissioning Authority (NDA) has

produced a guidance document [Ref-32] for Packaged ILW stores which is directed at the NDA's legacy sites and may be applied where similar stores are necessary on the UK ABWR sites. Packaged and stored ILW will be accessible to allow retrieval at any time during interim storage for inspection, assay and remediation as required.

10.4.4.2 Sludge (Crud)

Sludge is a form of wet ILW that results from the filtration of liquids from fuel cooling pools, active drains and from the settlement of process residues and corrosion products, as described in PCSR Chapter 18 Radioactive Waste Management, sections 18.5 and 18.6 [Ref-7]. They are treated in the UK ABWR in the Spent Resin and Sludge system (SS) arising from backwashing of various filters from the CF facility and LCW systems. The waste from the CF system will be within the ILW category as it arises from the condensate system after the steam has passed through the turbines. The particulate radioactivity will comprise small quantities of corrosion product which may have been carried over with the steam.

The LCW system collects wastes from various sources including the R/B, T/B and Rw/B drains, and processes them via filters, demineraliser and sampling tanks. The sludge will arise from backwashing the filters.

10.4.4.3 Powder Ion Exchange Resins

The Reactor Water Clean-up System (CUW) and FPC filter demineralisers process the main reactor circuit feed water and the water used in the SF cooling pool, as described in PCSR Chapter 18 Radioactive Waste Management, sections 18.5 and 18.6 [Ref-7]. This stream comprises the powder resins which are used for removal of dissolved radioactivity and will include any particulate sludge which is filtered from the CUW and FPC systems comprising particles of metal oxide (iron oxide and others) in the reactor water/SFP water. These resins are discharged, together with any entrained particulate sludge, when the particulate capture capacity of the resin is exhausted.

The powder resins as used in Japan have a cross-linked polystyrene matrix. It is assumed that a similar material will be used for the UK ABWR as this resin material type is similar to those currently used for radioactive water clean-up in other UK reactor systems; for example, clean-up of cooling pool water in the Magnox reactors.

10.4.4.4 Higher Activity Metals

Higher activity metal wastes arise during operations, primarily from the Zircaloy fuel channels which surround each of the fuel bundles in order to contain the boiling water region. The fuel channels are approximately 4.3 m long, 15 × 15 cm square and used to be removed from the fuel bundle assembly after a period of cooling in the SFP. In Japanese current practice, the fuel channels are stored with the spent fuel bundle as an assembly in the SFP. The fuel bundle and fuel channel are later dispatched together for further storage prior to reprocessing.

For the UK ABWR, for GDA, it will be assumed that the fuel channels will be consigned with the SF and not removed from the fuel assembly on discharge from the reactor. As it is assumed that the UK practice will not be to reprocess the SF, this option could be advantageous. It will eliminate any need to store and process or package the fuel channels as ILW, with attendant benefits in reducing operator dose and avoiding the cost and environmental impact of any processing/packaging facilities. The additional volume of the fuel channels around the fuel bundle will not significantly increase the number of storage or disposal packages and is not anticipated to adversely affect the disposability of the SF. Adoption of this approach will be subject to a satisfactory disposability assessment by RWM and future development by the site operator.

The other main contributor to the activated metals stream during the operational period is the control rods. The control rods used in the UK ABWR are of the following two types [Ref-33]:

Control rods for shutdown include stainless steel tubes filled with boron carbide powder. The high thermal neutron capture property of boron carbide is required for effective reactor shutdown. Use of boron carbide rods to fine control reactor power is avoided as far as practicable as lithium and helium isotopes are produced under neutron capture resulting in a decrease in efficiency over time.

Control rods for core reactivity control are made of hafnium material which has a significant, yet lower, thermal neutron capture cross section and a larger epithermal neutron capture cross section than boron carbide. The hafnium neutron capture isotopes also have an appreciable absorption cross section resulting in a longer useful lifetime as a power control rod than an equivalent boron carbide control rod.

By using the 2 types of control rods for their specific purposes, the control rod waste arising is minimised.

Both types of control rod are of cruciform shape metallic construction and approximately the same length as the fuel channels. There are on average likely to be about 5 hafnium units/year[1] and 176 boron carbide units/30 years arising [Ref-33].

Japanese practice for these items is to store in a water filled bunker. The control rods from the UK ABWR may be managed in a number of ways. Current UK practice with gas reactors is to store activated metals in a dry, usually shielded 'vault' facility. Dry cask storage also provides an interim storage option. This allows a period of decay to minimise dose to operatives and to simplify facility requirements when packaging is eventually undertaken.

For the boron carbide type of control rod which incorporates sealed tubes containing boron carbide powder as the neutron absorber, the size reduction technique will need to avoid and/or control breaching the tubes. The implication of the presence of hafnium material also needs consideration. The envisaged quantity of these items over the operational life is approximately 30 t; hence further consideration by the site operator will be necessary to develop an acceptable BAT case for the optimum solution.

The main disposal package options for these items are 3 m^3 stainless steel boxes, 500 litre stainless steel drums or robust containers which are self-shielded and are also qualified as transport containers. For the latter category there are a number of ductile cast iron container (DCIC) products of different sizes available.

A number of other items have been identified. These include various reactor core components from the Start-up Range Neutron Monitor (SRNM) and Low Power Range Monitor (LPRM) systems.

10.4.4.5 Irradiated Metal (Decommissioning)

Where irradiated metal which is determined to be HAW arises during decommissioning, this can be dealt with in a similar manner to the HAW metals noted previously, subject to acceptability via the LoC process. Although the management strategy may be similar to activated HAW metals generated during the site operations phase, consideration of the following will be required:

- Size reduction of the RPV and RIN (in-situ and ex-situ);
- Treatment of cutting pool water and management of secondary wastes;

[1] Design basis

- Potentially reduced in-pool interim (decay) storage time available depending on decommissioning schedule.

A baseline waste management process description for these decommissioning wastes is given in section 10.9.3.

10.4.5 Conditioning Option Descriptions: Intermediate Level Waste

The ILW conditioning options presented in this section have been considered during the GDA process. Subsequent optioneering assessments to select preferred options (Section 10.8) and conceptual design studies of waste management facilities capable of delivering the preferred waste treatment and disposal options have been carried out (Sections 11.3, 11.4 and 11.5).

10.4.5.1 Sludge / Crud and Ion Exchange Resin Conditioning Options

The conditioning options are presented in Figures 10.4.5-1 and 10.4.5-2 below, with additional details given in the accompanying notes.

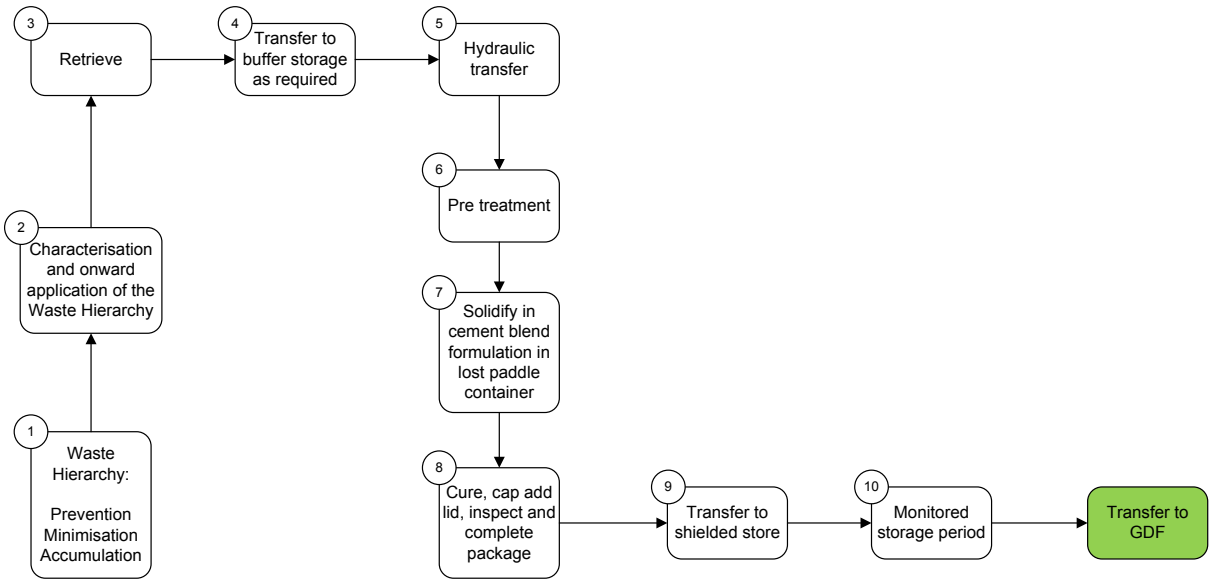


Figure 10.4.5-1: ILW; Solidification of Sludge/Crud and Ion Exchange Resin

Notes for Figure 10.4.5-1: ILW; Solidification of Sludge/Crud and ion exchange resin

1. The waste hierarchy will be applied to design and operation to minimise the volumes of waste accumulated. Expected waste characteristics and rate of arising are estimated in advance based upon plant design and operation. The wastes are accumulated in suitable controlled facilities in accordance with current UK practice to ensure adequate containment and control of the materials and that subsequent retrieval for onward processing and disposal can be undertaken in accordance with BAT principles and regulatory expectations. The wastes are identified in Appendix A of this arrangements document as Sludge (Crud) and Powder Resin (which also contains particulate corrosion products).
2. All wastes are managed in accordance with the Waste Hierarchy to ensure that final waste volumes are minimised. A future site operator's characterisation data will need to be sufficient to ensure that each waste stream is dealt with in an optimal manner according to its type and to enable the provision of

adequate data for the applicable waste route. This enables adequate justification of compliance with the specifications and guidance as published by RWM [Ref-28] to adequately inform the LoC process such that an LoC can be issued in due course, subject to RWM's disposability assessment. The characterisation data may be obtained at an appropriate point in the process where the waste stream is homogenised by a mixing/recirculation technique to ensure that samples which are representative of the bulk of the stream are obtained.

3. The waste streams are retrieved from their accumulation facilities using an appropriate standard UK technique. This technique utilises equipment which is installed within the accumulation facility and may comprise mixers to ensure that the wastes are homogeneous and suction devices which are capable of extraction of the waste stream slurry at the solids concentration which would be determined by the characterisation information.
4. Buffer storage of a batch of waste may be necessary to ensure that the subsequent process is adequately controlled, or this facility may be required to allow for a waste solidification campaign to be undertaken when a sufficient quantity of waste has been accumulated. This then allows further quantities of waste to be added to the accumulation facility to ensure that normal operations are not held up. This buffer storage facility may also be the point at which the sampling is undertaken to obtain the characterisation data noted in step 2 above.
5. Transfer of the waste stream from the buffer tank to the waste packaging process uses an appropriate UK standard technique for delivering a measured quantity of waste of defined properties to the waste container. The control of the transfer equipment integrates with the downstream equipment to ensure that waste delivery complies with the overall process to produce a predictable waste package (defined as the combination of the disposal container and the wasteform produced within it) in accordance with the requirements of the LoC. In this case the overall integrity of the waste package is mostly provided by the properties of the cemented contents with a minor contribution claimed for the container.
6. A pre-treatment step may be necessary to adjust and/or optimise the properties of the waste stream to adjust such properties as (for example) the solids concentration or the pH. This is to ensure compatibility with the packaging requirements and solidification formulation which has been demonstrated to RWM via the LoC process to produce satisfactory, disposable, wasteform properties. The pre-treatment step is conducted either in the buffer tank or disposal container depending on what is required and the waste properties. For example, reducing the water content of the ion exchange resin stream can be undertaken via a submerged filter within the disposal container whereas to reduce water content within a sludge stream may require some external equipment such as a settling tank or filter system.
7. Solidification of the waste stream is conducted within a UK standard container, which is compliant with the appropriate RWM specification. These containers are manufactured from austenitic stainless steel (typical grade 316L or EN 1.4404 to BS EN 10088-2:2005) and incorporate an integral mixing paddle which remains with the wasteform once it has been generated within the container. Typical container sizes, as used in the UK for many legacy site wastes, include 500 litre and 3 m^3 drums.

   The cement blend and quantity added are as defined for the specific waste stream. This is based upon formulations as used in Japan for these wastes or as for similar wastes, which have arisen at legacy sites and have been solidified in the UK. The formulation will have been previously endorsed by RWM via the LoC process as producing a wasteform of adequate properties, in compliance with the relevant specifications, as noted above. The long term evolution of the wasteform will also have been demonstrated. Both of these aspects will have been demonstrated by suitable supporting development trials with non-radioactive simulants or based upon directly applicable supporting data from (for example) Japanese or UK practice.

8. After production and curing of the wasteform within the disposal container the process is completed by addition of an inert grout cap to minimise the residual voidage within the package. The lid is then fitted and sealed with a bolted closure. The package is then visually inspected and the external surfaces are swabbed to ensure that any contamination is within the limits required for onward transport and interim storage on site.
9. The packages are transferred to an on-site ILW store using a suitable shielded route. Depending upon the site layout this may be via a shielded transporter or a shielded route/tunnel which is part of the site infrastructure.
10. The site includes a store which is suitable for the interim storage (for a period up to 100 years) of the ILW packages. The store is built to standard UK requirements and includes addressing of the guidance published for ILW stores for UK legacy sites [Ref-32].

    This guidance document provides for an integrated approach to the overall storage system by considering package and store performance as a whole; identification of good practice, principles, approaches and the use of 'toolkits' for specific analyses; e.g. package evolution and performance models; requirements for package care and management, including monitoring, identifying ideal, tolerable and failing performance parameters. Where monitoring indicates deterioration, such that some packages may not be suitable for eventual disposal, suitable 'reworking' schemes will be developed which may, in exceptional circumstances require re packaging of specific waste packages.

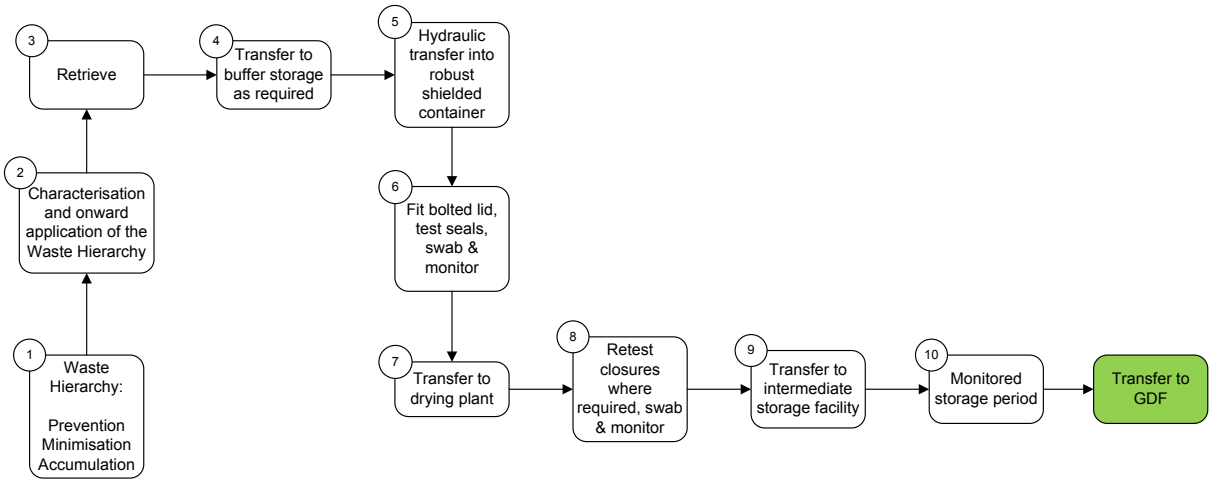


Figure 10.4.5-2: ILW; Drying of Sludge/Crud and Ion Exchange Resin

Notes for Figure 10.4.5-2: ILW; Drying of Sludge/Crud and ion exchange resin

1. The waste hierarchy will be applied to design and operation to minimise the volumes of waste accumulated. The wastes are accumulated in suitable controlled facilities in accordance with current UK practice to ensure adequate containment and control of the materials and that subsequent retrieval for onward processing and disposal can be undertaken in accordance with BAT principles and regulatory expectations. The wastes are identified in Appendix A of this arrangements document as Sludge (Crud), Powder resin (which also contains particulate corrosion products).
2. All wastes are managed in accordance with the Waste Hierarchy to ensure that final waste volumes are minimised. The characterisation data is sufficient to ensure that each waste stream is dealt with in an optimal manner according to its type and to enable the provision of adequate data for the applicable

waste route. This enables adequate justification of compliance with the specification as published by RWM [Ref-29] to adequately inform the LoC process such that a LoC can be issued in due course, subject to RWM's disposability assessment. The characterisation data may be obtained at an appropriate point in the process where the waste stream is homogenised by a mixing/recirculation technique to ensure that samples which are representative of the bulk of the stream are obtained.

3. The waste streams are retrieved from their accumulation facilities using an appropriate standard UK technique. This technique utilises equipment which is installed within the accumulation facility and may comprise mixers to ensure that the wastes are homogeneous and suction devices which are capable of extraction of the waste stream slurry at the solids concentration which would be determined by the characterisation information.
4. Buffer storage of a batch of waste may be necessary to ensure that the subsequent process is adequately controlled, or this facility may be required to allow for a waste packaging campaign to be undertaken when a sufficient quantity of waste has been accumulated. This allows further quantities of waste to be added to the accumulation facility to ensure that normal operations are not held up. This buffer storage facility may also be the point at which the sampling is undertaken to obtain the characterisation data noted in Step 2 above.
5. Transfer of the waste stream from the buffer tank to the waste packaging process uses an appropriate UK standard technique for delivering a measured quantity of waste of defined properties to the waste container. The control of the transfer equipment is integrated with the downstream equipment to ensure that waste delivery complies with the overall process to produce a predictable waste package (defined as the combination of the disposal container and the wasteform produced within it) in accordance with the requirements of the LoC. In this case the overall integrity of the waste package is provided by the robust container and none would be claimed for the waste contents.

   The robust container would be one of a number of designs currently being considered within the UK by some legacy sites (e.g. Magnox Limited) and at the Sizewell B PWR. They are manufactured from ductile cast iron, a material which is readily formed into the required shape by casting/machining and whose properties are enhanced by the metal composition and controlled cooling to increase the material's ductility. Robust shielded containers are currently available from suppliers such as Gesellschaft für Nuklear-Service mbH (GNS) and Croft Ltd.

6. Depending upon the layout of the retrieval equipment and the rest of the process plant the container may then be sealed at this point by addition of a sealed lid secured by bolts. If the container's location was in a contamination controlled area the container's external surfaces would also be swabbed and monitored prior to transfer to later stages in the process to ensure that contamination levels are within allowable limits.
7. The waste within the container is dried by removal of bulk water and as much interstitial moisture as required in order to achieve the required dryness level. This process requires penetrations to be made into the container for the application of a vacuum, and some external heating will also be applied to achieve this dryness. The process plant will include appropriate monitoring equipment to measure the residual moisture content and hence determine an end point for the drying process.
8. After the required dryness level is achieved the process equipment is disconnected and the container resealed by insertion of appropriate closures, which will be tested for leak tightness. The container's external surfaces would again be swabbed and monitored to ensure that contamination levels are within allowable limits.
9. The packages are transferred to an on-site ILW interim storage facility using a suitable route. Depending upon the site layout this may be via a suitable transporter or a route/tunnel which is part of the site infrastructure.

10. The site includes a store which is suitable for the interim storage (for a period up to 100 years) of the ILW packages. The store will be built to standard UK requirements and may include addressing of the guidance published for ILW stores for UK legacy sites [Ref-32]. However, the applicability of this guidance will be reviewed as it was developed by the NDA for shielded stores which are intended for the long term interim storage of unshielded ILW packages, mostly comprising cemented wasteform within thin walled stainless steel containers.

10.4.5.2 Activated Metals Conditioning Options

The conditioning options are presented in Figures 10.4.5-3 and 10.4.5-4 below, with additional details given in the accompanying notes.

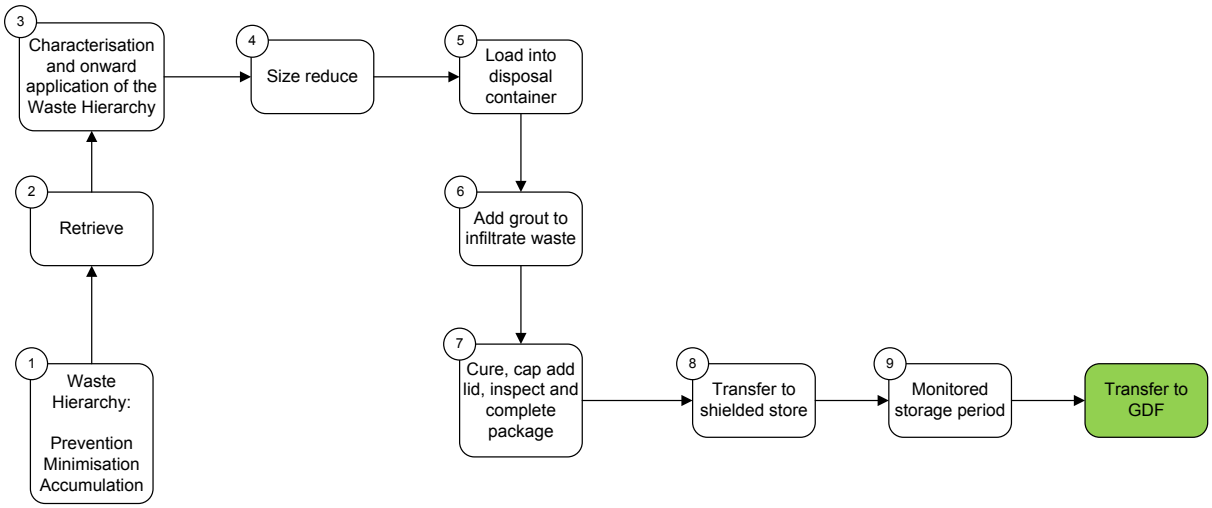


Figure 10.4.5-3: ILW; Encapsulation of Activated Metals

Notes for Figure 10.4.5-3: ILW; Encapsulation of Activated Metals

1. The waste hierarchy will be applied to design and operation to minimise the volumes of waste accumulated. The wastes are accumulated in suitable controlled facilities in accordance with current UK practice to ensure adequate containment and control of the materials and that subsequent retrieval for onward processing and disposal can be undertaken in accordance with BAT principles and regulatory expectations. The wastes are identified in Appendix A of this arrangements document as Higher Activity Metals; Control Rods, Fuel Channels[2] & Others. The method of accumulation in Japan is within a 'wet bunker' where the items also undergo size reduction prior to placing in containers and grouting. The means of accumulation for UK ABWR may follow UK practice for gas reactor legacy sites where such items are accumulated in dry shielded vault stores. Interim decay storage may similarly be achieved within the SFP and subsequent transfer to dry storage canisters and overpacks.
2. The waste streams are retrieved from their accumulation facilities using an appropriate standard UK technique. The method of retrieval is determined by the requirements of the overall process and will

[2] Note it is assumed for GDA that these items remaining with the spent fuel assemblies and are managed/packaged as part of this stream.

be significantly influenced by how the items are to be accumulated (i.e. in a wet or a dry facility) and where it is appropriate to conduct subsequent operations, especially size reduction.

3. All wastes are managed in accordance with the Waste Hierarchy to ensure that final waste volumes are minimised. The characterisation data is sufficient to ensure that each waste stream is dealt with in an optimal manner according to its type and to enable the provision of adequate data for the applicable waste route. This enables adequate justification of compliance with the specifications and guidance as published by RWM [Ref-28] to adequately inform the LoC process such that an LoC can be issued in due course, subject to RWM's disposability assessment. The characterisation data may be obtained at an appropriate point in the process. For example, a gamma assay station may be incorporated within the facility where the items are loaded into a disposal container.
4. The waste items are size reduced in a suitable facility which ensures that the operations can be conducted according to BAT principles, including maintaining worker dose uptake ALARA. The design of the facility depends upon the accumulation method chosen. Where accumulation is in a wet bunker the necessary shielding is provided by the depth of water. In this case underwater techniques are used to size reduce. Where the items have been accumulated in a dry storage environment the necessary shielding is provided by a suitable shielded cell or the size reduction may be undertaken within the dry storage facility. The size reduction techniques comprise cutting (in a manner to limit secondary waste; e.g. shearing) and compaction. The latter technique will take into account the need for adequate grout infiltration during the subsequent packaging operation.
5. The items are loaded into a suitable UK standard container, which is compliant with the appropriate RWM specification. These containers are manufactured from austenitic stainless steel (typical grade 316L or EN 1.4404 to BS EN 10088-2:2005). Typical container sizes, as used in the UK for many legacy site wastes, include 500 litre drums and $3m^3$ boxes.
6. Encapsulation of the waste stream is conducted within the container by addition of a suitable cement grout to produce a predictable waste package (defined as the combination of the disposal container and the wasteform produced within it) in accordance with the requirements of the LoC. In this case the overall integrity of the waste package is mostly provided by the properties of the cemented contents with a minor contribution claimed for the container.

   The cement blend and quantity added is as defined for the specific waste stream. This is based upon formulations as used in Japan for these wastes or as for similar wastes, which have arisen at legacy sites and have been encapsulated in the UK. The formulation will have been previously endorsed by RWM via the LoC process as producing a wasteform of adequate properties, in compliance with the relevant specifications, as noted above. The long term evolution of the wasteform will also have been demonstrated. Both of these aspects will have been demonstrated by suitable supporting development trials with inactive simulants or based upon directly applicable supporting data from (for example) Japanese or UK practice.
7. After production and curing of the wasteform within the disposal container the whole package is completed by addition of an inactive grout cap to minimise the residual voidage within the package and fitting of the container lid by a sealed bolted closure. The package is inspected via visual means and swabbing the external surface to ensure that any contamination is within the limits required for onward transport and interim storage on site.
8. The packages are transferred to an on-site ILW store using a suitable shielded route. Depending upon the site layout this may be via a shielded transporter or a shielded route/tunnel which is part of the site infrastructure.
9. The site includes a store which is suitable for the interim storage (for a period up to 100 years) of the ILW packages. The store will be built to standard UK requirements and will include addressing of the guidance published for ILW stores for UK legacy sites [Ref-32].

This document provides guidance for an integrated approach to the overall storage system by considering package and store performance as a whole; identification of good practice, principles, approaches and the use of 'toolkits' for specific analyses; e.g. package evolution and performance models; requirements for package care and management, including monitoring, identifying ideal, tolerable and failing performance parameters. Where monitoring indicates deterioration, such that some packages may not be suitable for eventual disposal, suitable 'reworking' schemes will be developed which may, in exceptional circumstances require re packaging of specific waste packages.

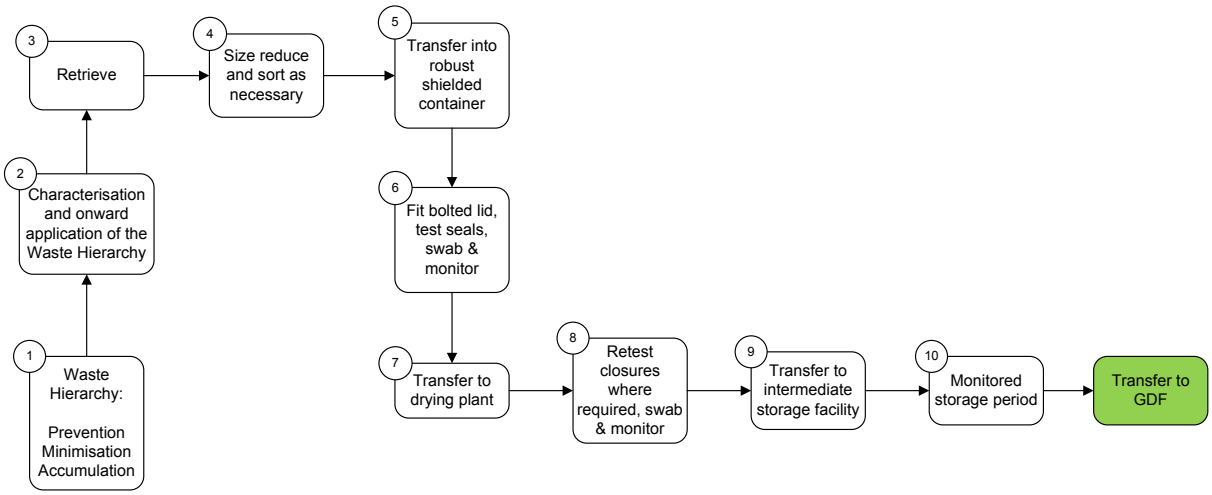


Figure 10.4.5-4: ILW; Drying of Activated Metals

Notes for Figure 10.4.5-4: ILW; Drying of Activated Metals

1. The waste hierarchy will be applied to design and operation to minimise the volumes of waste accumulated. The wastes are accumulated in suitable controlled facilities in accordance with current UK practice to ensure adequate containment and control of the materials and that subsequent retrieval for onward processing and disposal can be undertaken in accordance with BAT principles and regulatory expectations. Higher Activity Metals; Control Rods, Fuel Channels[3] & Others. The method of accumulation in Japan is within a 'wet bunker' where the items also undergo size reduction prior to placing in containers and grouting. The means of accumulation for UK ABWR may follow UK practice for gas reactor legacy sites where such items are accumulated in dry shielded vault stores. Interim decay storage may similarly be achieved within the SFP and subsequent transfer to dry storage canisters and overpacks.
2. All wastes are managed in accordance with the Waste Hierarchy to ensure that final waste volumes are minimised. The characterisation data is sufficient to ensure that each waste stream is dealt with in an optimal manner according to its type and to enable the provision of adequate data for the applicable waste route. This enables adequate justification of compliance with the specification as published by RWM [Ref-29] to adequately inform the LoC process such that a LoC can be issued in due course, subject to RWM's disposability assessment. The characterisation data may be obtained at an

[3] Note it is assumed for GDA that these items remain with the spent fuel assemblies and are managed/packaged as part of this stream.

appropriate point in the process. For example, a gamma assay station may be incorporated within the facility where the items are loaded into a disposal container.

3. The waste streams are retrieved from their accumulation facilities using an appropriate standard UK technique. The method of retrieval is determined by the requirements of the overall process and is significantly influenced by how the items are to be accumulated (i.e. in a wet or a dry facility) and where it is appropriate to conduct subsequent operations, especially size reduction.
4. The waste items are size reduced in a suitable facility which ensures that the operations can be conducted according to BAT principles, including maintaining worker dose uptake ALARA. The design of the facility depends upon the accumulation method chosen. Where accumulation is in a wet bunker the necessary shielding is provided by the depth of water. In this case underwater techniques are used to size reduce. Where the items have been accumulated in a dry storage environment the necessary shielding is provided by a suitable shielded cell or the size reduction may be undertaken within the dry storage facility. The size reduction techniques comprise cutting (in a manner to limit secondary waste; e.g. shearing) and compaction.
5. Transfer of the waste stream to the waste packaging process uses an appropriate UK standard technique for delivering a measured quantity of waste of defined properties to the waste container. At this stage the waste may be characterised by gamma assay or similar. The control of the transfer equipment is integrated with the downstream equipment to ensure that waste delivery complies with the overall process to produce a predictable waste package (defined as the combination of the disposal container and the wasteform produced within it) in accordance with the requirements of the LoC. In this case the overall integrity of the waste package is provided by the robust container and none would be claimed for the waste contents.

   The robust container would be one of a number of designs currently being considered within the UK by some legacy sites (e.g. Magnox Limited) and at the Sizewell B PWR. They are manufactured from ductile cast iron, a material which is readily formed into the required shape by casting/machining and whose properties are enhanced by the metal composition and controlled cooling to increase the material's ductility. Robust shielded containers are currently available from suppliers such as Gesellschaft für Nuklear-Service mbH (GNS) and Croft Ltd.

6. Depending upon the layout of the retrieval equipment and the rest of the process plant the container may then be sealed at this point by addition of a sealed lid secured by bolts. If the container's location was in a contamination controlled area the container's external surfaces would also be swabbed and monitored prior to transfer to later stages in the process to ensure that contamination levels are within allowable limits.
7. The waste within the container is dried by removal of any residual bulk water and as much interstitial/adherent moisture as required in order to achieve the required dryness level. This process requires penetrations to be made into the container for the application of a vacuum, and some external heating is applied to achieve this dryness. The process plant includes appropriate monitoring equipment to measure the residual moisture content and hence determine an end point for the drying process.
8. After the required dryness level is achieved the process equipment is disconnected and the container resealed by insertion of appropriate closures, which are tested for leak tightness. The container's external surfaces would again be swabbed and monitored to ensure that contamination levels are within allowable limits.
9. The packages are transferred to an on-site ILW interim storage facility using a suitable route. Depending upon the site layout this may be via a suitable transporter or a route/tunnel which is part of the site infrastructure.

10. The site includes a store which is suitable for the interim storage (for a period up to 100 years) of the ILW packages. The store will be built to standard UK requirements and may include addressing of the guidance published for ILW stores for UK legacy sites [Ref-32]. However, the applicability of this guidance will be reviewed as it was developed by the NDA for shielded stores which are intended for the long term interim storage of unshielded ILW packages, mostly comprising cemented wasteform within thin walled stainless steel containers.

10.4.6 Borderline Wastes

Section 10.3.1 Waste Segregation and the Radioactive Solid Monitoring Requirements [Ref-10] illustrate how consideration of the waste provenance (material, usage, in-service routine monitoring) and characterisation enables effective onward waste management. Such an approach will also enable early identification and estimation of potential borderline waste characteristics and volume.

Where a specific waste stream is likely to be considered in the future as 'borderline' (i.e. it may be close to the LLW and ILW categorisation boundary), it will be assessed using a methodology agreed with the disposal suppliers (e.g. LLWR and RWM) and UK regulators as appropriate. LLWR Ltd. has published guidance [Ref-34] containing a number of decision making factors for consideration. The guidance document has been developed in conjunction with RWM and its application will be linked with both the LoC process and the waste acceptance criteria adopted by LLWR.

RWM is currently considering several aspects related to borderline wastes which include:

- Use of decay storage for up to 300 years for some short lived radionuclides;
- Further development of the LLWR boundary wastes report [Ref-34] to better optimise the balance between LLW and ILW;
- Specific consideration of tritiated wastes and whether to decay store or remove the Tritium;
- Consideration, in conjunction with LLWR Ltd. to manage the wastes via the disposal facility safety case rather than purely the Waste Acceptance Criteria.

Developments in this area by LLWR Ltd. and RWM will be monitored, possibly by the site operator via the relevant User Groups for the LLWR and the GDF, when waste management practices are being planned for implementation, to ensure that the optimal route for specific waste streams are chosen.

10.4.6.1 The CD and LCW Demineraliser Resins

The definition of LLW/ILW Cross-Boundary Waste given in [Ref-34] as *ILW and LLW with a concentration of specific radionuclides that prohibits or significantly challenges its acceptability at existing and planned future disposal facilities for LLW, that could practicably be managed as LLW (on the basis of radiological and physico-chemical properties) through application of some treatment process or decay storage.*

The CD, LCW and HCW resins are detailed in Appendix A: Waste Stream and Spent Fuel Descriptions, Table A2.2-2: Details of LLW Bead Resins. The CD and LCW demineraliser resins demonstrate specific activities of >12 GBq/t beta gamma at arising which classifies them as ILW. However, the BAT selected option (section 10.8) is processing at maximum waste loading in a solidification matrix (cement). As a part of the solidification process, the specific radioactivity of the final waste form is calculated to be <12 GBq/t beta gamma and therefore LLW at disposal. The calculated dose rates from a bulk treated waste form in cement, such as in a 1/3height ISO container (THISO), would challenge acceptable handling and transport dose rate limits and therefore keeping dose to the public and worker ALARA. The radioactivity of the resins is dominated by Co-60 and Fe-55 with radioactive decay half-lives of 5.27 and 2.7 years respectively

and therefore decay storage for a period of time will significantly reduce the total radioactivity and dose rate. The CD and LCW resins meet the definition of cross-boundary waste as defined in [Ref-34].

Consideration of LC32 and LC34 (6.3)

The accumulation of waste should be minimised and measures taken to prevent waste leakage. Decay storage will, by its nature, accumulate waste on site. Decay storage as raw waste in the resin storage tank beyond the period necessary to manage batch processing accumulates waste in a form with the potential to leak in a fault condition. Decay storage of an immobilised waste form that has an agreed final disposal route demonstrates temporary accumulation as part of the management process in a simple and stable form that minimises the potential leakage and escape of radioactive material. However, decay storage prior to processing may be demonstrated to reduce risk, for example radiation dose uptake, during processing and from the storage of final waste package ALARA. The final decay storage solution will consider all factors to demonstrate an optimised solution.

Disposal as LLW

Subject to discussion and agreement with the LLWR following their waste enquiry process, appropriate treatment and decay storage will render the resins disposable as LLW. A minimum decay storage period of approximately 8 years is envisaged, however, this will depend on the radioactivity of the resin at arising. It should be noted that the specific activities presented in Appendix A, Table A2.2-2 may be considered conservative. The Japanese experience of treating their bead resins by incineration and direct cementation according to the variation in specific radioactivity of spent resin batches illustrates that the radioactivity on the resins can vary according to reactor operation conditions.

The relatively low specific radioactivity resins that are incinerated on-site in Japan are expected to be above the specific radioactivity and waste package dose rates quoted by UK hazardous waste incinerator service suppliers in their WAC [Ref-25].

The application of decay storage when necessary and immobilisation in cement will provide a disposable LLW waste form subject to LLWR acceptance following the LLWR waste enquiry process. The waste conditioning process will be demonstrably BAT, maintaining risks to the public, the worker and the environment ALARA.

Characterisation

A robust monitoring system to calculate and measure the condition of the CD and LCW bead resins during operation will be maintained such that the spent resin will be within acceptable parameters based on the waste management facility safety case and disposal facility WAC.

There will need to be the capability for confirmatory sampling and characterization of the spent resin prior to treatment.

Cement Immobilisation Options

An appropriate cement immobilisation technique for lower specific radioactivity range LLW bead resins includes in-line mixing of wet resin waste and cement into a THISO. The advantage of processing directly into a THISO is that voidage is eliminated and waste volume minimised. As well as providing containment, the THISO is also the certified transport package. Due to transport package maintenance and certification requirements THISOs are not considered practicable decay storage containers. In-line mixing into a THISO will require the LLW bead resin to be within a specific radioactivity range such that the final waste package conforms to LLWR acceptance criteria and transport regulations. If decay storage is required, it must be of the raw waste prior to processing.

For higher specific activity range bead resins (cross-boundary LLW/ILW) cement immobilisation within disposal drums (e.g. 210 litre drums) followed by a period of decay storage within a shielded store and consignment for disposal to the LLWR within an approved transport and disposal ISO container (e.g. HHISO) is an alternative option to the THISO. The advantage of conditioning into drums with cement is that the cementation, on-site handling and decay storage processes may be carried out in a manner to maintain the dose to workers, the public and the environment ALARA.

Decay storage options

The capacity for safe decay storage of spent bead resin for between 5 and 10 years will be required to ensure immediate disposability of cemented bead resin waste in THISOs. An option is to use a number of resin settling tanks of appropriate size to future, regular, planned processing campaigns. Once the first tank is filled it is isolated and a second tank is brought into service. After an appropriate decay storage period the first tank contents are processed as part of a routine waste solidification cycle. Following processing the first tank, now empty, is returned to service and available to receive the next batch of spent resin whilst the second tank is isolated. The number of tanks required and the decay storage periods will be optimised.

Decay storage of solidified resin in drums will require a suitably shielded storage area. Location options include:

- A suitably sized decay store associated with the SWF and marshalling area (section 11.1).
- An appropriately shielded and accessible area or extension of the ILWS (section 11.5).

On-site transport may use shielded overpacks to maintain dose uptake ALARA.

In summary, the CD and LCW demineraliser resins can be shown to be disposable as LLW following the BAT option of conditioning in cement. There are packaging and decay storage options available to safely manage the disposal of the potentially cross-boundary resin waste as LLW. Further engagement with the LLWR will be required by the future site operator before and during the waste enquiry process (see 13.1).

The preferred option in GDA is to decay store the bead resin in tanks prior to processing in THISOs. The PCSR Chapter 18, section 18.6 [Ref-7] states that the bead resins and sludge wastes are received into a storage tank as the wastes arise and are stored to allow decay to LLW activity levels prior to a waste processing campaign. Four tanks are provided to allow sufficient storage capacity to allow decay storage to LLW levels. When sufficiently decayed the waste is sent to a processing tank where it is pre-treated in preparation for solidification into a grout matrix.

10.4.6.2 LCW filters

As described in section 8.1.2, filters are used to remove insoluble impurities in the LCW. When the differential pressure across the filter increases, the filter is backwashed to remove the particulate. When exhausted, the hollow fibre filters are raised out of the filter vessel, drained, monitored and prepared for transfer to the dry solid LLW waste processing system.

The LCW crud captured by the LCW filter is ILW (Appendix A ,Table A2.4-1). The radioactivity of the filter at retrieval from the filter unit will depend on the final backwash efficiency and is therefore subject to uncertainty. PCSR Chapter 18, section 18.12.1.3 [Ref-7] describes the LCW Filter Packaging Room process and includes the following points:

- When filter elements require discharge, the entire bank of filter elements is replaced as a unit.
- Once the LCW filter vessel has been opened, the entire filter matrix is removed from the vessel as one unit and placed into a 500 litre drum (the plant design can also utilise smaller drums if required).

- The normal operation will be to export filters out of the facility ungrouted, however, the filter can be grout encapsulated if required.
- After swabbing and monitoring, the 500 litre drum will be lifted over a dwarf wall and placed inside a shielded overpack..
- The final package is exported through the LLW Monitoring and Marshalling Area (MMA).
- A gamma ray spectrometer and dose meter will be in place within the filter removal area to allow initial characterisation of the final package as a period of decay will be required before it can be disposed of as LLW.

It is also stated in Chapter 18 that it is feasible that filters could be changed out early to minimise the build-up of high levels of crud that cannot be removed by backwashing however for GDA it is assumed early change-out is not undertaken.

The LCW filters are identified as a borderline waste in GDA that require a period of decay before being disposable to the LLWR. Shielded decay storage is anticipated to be within the SWF.

LCW filter management options are not foreclosed and the final choice of filter type, operational regime and waste management option will be chosen by the future licensee based on site specific BAT and safety assessment.

10.4.6.3 Operational ILW due to contamination

In GDA step 4, Hitachi-GE have responded to RQ-ABWR-1473 [Ref-59] outlining the options available to a future operator / licensee for the management of solid ILW arising during the operations phase of the UK ABWR. The design of the UK ABWR minimises the production of solid ILW and therefore no routine dry -solid ILW is anticipated. Any dry-solid ILW will be managed under “off-normal” conditions on a case by case basis by the future operator:

- Activated ILW will arise in the reactor and will be managed as for other activated core components (10.4.4, 11.4).
- The limited amount of dry-solid contaminated ILW could be managed using a similar strategy to that planned for decommissioning. ILW could be stored in either the shielded drum store in the SWF or in $3m^3$ boxes within the ILWS until the GDF is available or the waste has decayed to within LLW acceptance limits.
- Based on BAT assessment at the time, the future operator may apply limited decontamination techniques to the contaminated ILW to allow the wastes to be disposed of via available routes (10.4.7, 10.9.5).
- Currently, with the 60 year design life any waste volumes are expected to be low and not quantifiable at GDA. However, all wastes will be dealt with promptly on arising and will be stored in appropriate storage facilities that are available during normal operation.

10.4.6.4 Borderline wastes at decommissioning

The Decommissioning Waste Management document [Ref-17] recognises that the decommissioning waste inventory is subject to significant uncertainty and identifies a number of potential borderline wastes and management solutions. Records of the UK ABWR operational history and comprehensive measurement and characterisation campaigns at the start of, and during, decommissioning will inform the future operator of the potential for cross-border wastes and enable relevant waste management optimisation (BAT and ALARP) studies. The solutions proposed here do not foreclose options to the future operator, they simply demonstrate that consideration has been given at GDA to identify achievable waste management solutions that have a reasonable chance of being BAT.

Metal waste: RIN ILW / HLW Following RPV System Decontamination

An increase in RIN waste inventory from ILW to HLW, due to variation between the GDA estimate and characterisation at decommissioning, will not affect the overall waste management strategy as described in 10.9.3.2. Handling is remote and HAW, whether ILW or HLW, is proposed to be stored until the GDF is available.

The HAW inventory will be refined during operations and decommissioning by the future operator as part of the RWM LoC process.

Metal waste: RIN LLW / ILW following RPV System Decontamination

A potential increase in the RIN waste inventory from LLW to ILW will not affect the overall waste management strategies for LLW and ILW segregated at dismantling as described in 10.9.3.2. The relative reduction in LLW and increase in ILW will require a greater number of ILW storage packages. The design for the ILW store during decommissioning will require flexibility to accommodate an increase in package numbers. The HAW inventory will be refined during operations and into decommissioning by the future operator as part of the RWM LoC process.

Metal waste: RPV LLW / ILW Following RPV System Decontamination

A potential increase in the RPV waste inventory from LLW to ILW will not affect the overall waste management strategies for LLW and ILW segregated at dismantling as described in 10.9.3.2. However, since it is proposed that size reduction of RPV segments will take place in the DSP in air, there is the potential for increased dose uptake by the worker. The future site operator will base their waste management optimisation assessments on the radiological measurement and characterisation data at EoG and following RPV system decontamination.

Water treatment resins LLW / ILW

The current assumption for GDA is that resins used to clean up the plant retained water in decommissioning will be similar to those used in the LCW system during the operations phase and therefore similar waste management solutions may be utilised (see 10.4.6.1). However, it is unlikely that a decay storage option prior to processing will be available during the decommissioning phase and therefore potential options may include:

- Resin selection and / or operational procedures selected prior to the decommissioning phase to ensure that the spent resin will be of known waste classification and demonstrates BAT and ALARP optimisation in the operation and waste management processes;
    - Selection such that spent resin will be LLW and within the LLW resin processing and disposal safety case;
    - Selection such that spent resin will be ILW and within the ILW resin processing and disposal safety case, and;
- Selection of resin and system design that is compatible with processing and disposal via either the LLW or ILW waste management systems.

The future site operator will be responsible for selecting the final optimised solution. Selection will be based on the UK ABWR's operational history, measurement and characterisation campaigns and technological developments at the time. The options presented here do not foreclose any options available to the operator at the time, allowing optimised selection to be demonstrated BAT.

Underwater cutting filters LLW / ILW

During the underwater segmentation and size reduction operations on the RIN, water clean-up filters will capture swarf and other particulate. Due to the variation in radioactivity across the RIN, the filters may demonstrate a range of specific activities including those at the waste categorisation boundary LLW / ILW. A potential solution may be:

- Prediction of the filter radioactivity in advance through calculation;
- Radiological measurement of the filter at removal from service, segregation and direction to the appropriate LLW or ILW waste processing route, and;
- Prompt conditioning of LLW and ILW filters to immobilise the radioactive particulate and buffer storage prior to disposal.

The management of LLW and ILW RIN wastes are discussed in section 10.9.3.2. The availability of LLW and ILW waste treatment, conditioning and packaging options to the future licensee will enable the appropriate management of the cutting filter waste to be demonstrated BAT.

10.4.7 Decontamination of Operational Waste

The decontamination of waste items can, when applied appropriately, have the following benefits:

- Supporting the waste hierarchy by reducing the waste classification and enabling re-use, recycling or other, more sustainable treatment and disposal route;
- Reducing radiation dose exposure (including discharges to the environment) during handling, storage and disposal to ALARA;
- Reduction or elimination of potential contamination dispersal by removal and fixing of loose contamination.
- Ensuring that waste items are compliant with waste management facility (on or off site) safety cases and acceptance criteria;
- Reducing subsequent treatment and disposal costs.

Decontamination techniques must be appropriate to the waste items and their treatment / disposal route. If applied inappropriately the results could produce:

- An orphan waste stream with no identifiable disposal route;
- A significant increase in radioactive waste volume;
- Increased dose uptake to operators;
- Increased discharge to the environment;
- More expensive waste management processes.

In keeping with the waste hierarchy and the prevention of waste generation, the UK ABWR has been designed to minimise contaminated plant areas, which minimises contaminated waste, minimises the need for decontamination and maximises the chances of clearance and exemption of waste.

The following is assumed for operational wastes:

- Activated metals (control rods, other non-fuel activated wastes) taken from the reactor will be dominated by activation products. Surface contamination will be relatively low with respect to the activation radioactivity and remote handling and effective containment is required by the treatment, storage and disposal facilities due to the dose rate. Decontamination holds no advantage.

- Simple decontamination of LAW metals may include dismantling of equipment, wiping off loose contamination or a water wash where practicable and demonstrably BAT to achieve suitably low levels of contamination for consignment to a suitable treatment, recycling and disposal supplier. It is noted that the specialist metal treatment and recycling suppliers mentioned in the LLWR Ltd. Waste Services Contract document “Waste Acceptance Criteria – Metallic Waste Treatment” [Ref-36] can offer decontamination, recycling and disposal of secondary waste services.

- For other miscellaneous LAW, simple "wipe-down" decontamination as appropriate at waste source is assumed as a part of routine work safety procedures to ensure that spread of contamination is minimised and controlled.

Section 10.9 of this strategy document identifies other potential decontamination techniques and the potential secondary waste arisings during decommissioning. The final decision of technique to use for decontamination will be made by the future site operator following detailed BAT assessment to ensure that all decontamination techniques are applied appropriately.

10.5 Spent Fuel

Based upon the Government White Paper 'Meeting the Energy Challenge' [Ref-37], the current assumption for the management of SF from new build is not to reprocess. This document specifically states that '*unless otherwise stated, references to the Government position on waste refer to "higher activity waste", which includes intermediate level waste and spent fuel from any new nuclear power stations*'. Therefore, following a period of cooling in the SF storage Pool (SFP) the SF will be stored and packaged appropriately and disposed of once a GDF is available.

SF is produced only during the operational phase of the reactor. However, all of the SF stored in the fuel cooling pool, after final shutdown, is assigned to the decommissioning phase. From a technical perspective there is no difference between these two phases and all SF will be managed using the same strategy.

A small number of fuel assemblies may experience defects. The characteristics of these are being discussed with RWM as part of the disposability assessment and any specific measures to manage them agreed. The main defects that are likely to occur during a 60 years operational lifetime are fuel rod defects caused by debris fretting or pellet-cladding interaction (PCI), for which the following mitigation technologies have been introduced:

- Debris filters – Incorporated with or above the fuel bundle lower tie plate, debris filters and shields have been developed to reduce the size of debris entering the fuel bundle. As a consequence the fuel failure rate has been reduced to 0.5 failed bundles per 1000 bundles (0.05%) [Ref-8].
- Barrier cladding in the fuel design – a physical barrier (e.g. a thin zirconium layer) to minimise PCI.
- Improved manufacturing and quality assurance procedures during pellet manufacture – prevents chipped pellets being loaded into the fuel rod and thus avoiding PCI.
- Operating strategies to minimise the risk of PCI.

Improvements to fuel design, manufacture and operation, including the mitigation technologies identified above, are described in more detail in the Demonstration of BAT document, Argument 1a: Design, manufacture and management of fuel [Ref-8].

At the highest level there are several options available for the long term on-site storage of SF in the UK. The following sections describe the SF characteristics from a UK ABWR and the options for packaging, interim storage and disposal. These options are based upon good practice as currently applied in other countries (and one option planned for implementation at Sizewell B) and which would be considered as BAT at this time.

10.5.1 Fuel Characteristics

The GE14 fuel assembly consists of a fuel bundle (composed of fuel rods, water rods, spacers, and upper and lower tieplates), and a channel that surrounds the fuel bundle (Figure 10.5.1-1). This fuel type has 92 fuel rods (fourteen partial length rods) in a 10 × 10 rod array and two large central water rods. The fuel rods

and water rods are spaced and supported by the upper and lower tieplates with intermediate spacing provided by eight spacers. The upper and lower tieplates are fixed by eight tie rods, which hold the fuel bundle together. The upper tieplate has a handle for transferring the fuel assembly.

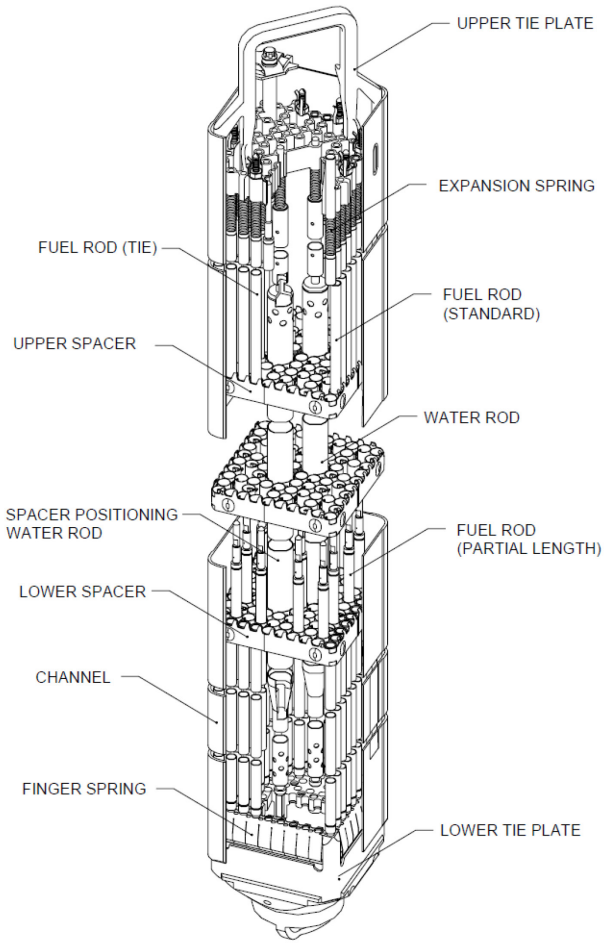


Figure 10.5.1-1:GE14 Fuel Assembly

The assumed cooling period for SF before geological disposal is a minimum of 140 years. General information for fuel and plant operation is shown in Table 10.5.1-1.

Table 10.5.1-1: General Information for Fuel and Plant Operation

Item	Value
Power (MWt)	3,926
Operational cycle (month)	18
Average discharged fuel burn-up (GWd/tU)	50
Weight of uranium oxide (UO_2) per assembly (kg)	200*
Total number of fuel assemblies discharged over 60 years operation	9,600*

*: approximate

As noted in section 10.4.4.4, as the SF will not be reprocessed, the zircaloy fuel channels which surround each of the fuel bundles are to remain with the SF for co-disposal.

10.5.2 Packaging Options

The SF assemblies are stored in the SFP to allow the heat output and radioactivity levels to reduce. The SF is then be transferred to another on site storage facility prior to it being re-packaged, if required, for disposal in the GDF.

The option to store the fuel channel with the SF bundle has been considered for minimising waste volumes and avoiding the potential operator dose associated with removal of them and subsequent size reduction. It is assumed for GDA that the fuel channels remain with the SF and hence the treatment/packaging of them is the same as for the SF.

Management of any defective/failed fuel bundles/assemblies is to be determined. Options for the on-going management of the SF will be subject to a satisfactory disposability assessment by RWM, and will include the following candidate packaging/storage options:

10.5.2.1 Dry Cask

Current Japanese practice is to remove SF assemblies from the SFP after an appropriate period and load them into large shielded casks capable of storing the SF. The casks could then be used for transport, after fitting of suitable high performance shock absorbers, to a central interim storage site, if appropriate.

The SF assemblies are sealed within leak-tight casks and surrounded by an inert gas. Two types of cask system are available:

- Concrete – a number of SF assemblies are placed in a stainless steel canister which is welded shut before being placed into a concrete outer casing
- Metal – the SF assemblies are placed into a metal cask which is sealed and bolted shut

Both systems are designed to provide protection against external hazards and provide adequate radiation shielding to both the site workforce and members of the public. There are a number of dry storage container designs in use around the world and different designs can be used for storage, transportation or both.

The SF assemblies would need to be prepared for transport to and disposal in a GDF by removal from the cask storage into another container which would be suitable for transport and acceptable for disposal. Such a disposal container may be as described in 10.5.2.4 .

10.5.2.2 Multi-Purpose Container

Multi-Purpose Containers (MPC) are proposed as appropriate packages for safe interim storage of SF.

There are MPC systems in use in the USA that are currently under consideration for use in the UK. For example, the Holtec system, similar to that shown in [Ref-38] has been proposed for Sizewell B PWR SF, which accommodates 24 assemblies in a single MPC. Use of this container has been assessed by RWM [Ref-39]-44] which concluded that use of this MPC would require re-packaging for disposal.

As an optimisation opportunity, development of a MPC system that could potentially be used for both interim storage and disposal, thus minimising handling and keeping dose uptake ALARA may be assessed for use with the UK ABWR SF as part of the future site operator's BAT selection process.

10.5.2.3 Modular Vault Dry Storage System

Dry vault storage is a method, already used in many other countries for storing spent nuclear fuel that has already been cooled in the SFP. In this concept individual fuel assemblies are stored within sealed channels within the shielded vault. Current examples of these vaults have been built in such a way that additional storage vault capacity can be constructed when needed as new modules.

After removal from the reactor the SF assemblies would be loaded into a shielded transfer cask in the R/B. The cask would then be sealed and decontaminated before being taken to the vault store. Here, the fuel assemblies would be lifted from the cask and dried. A shielded fuel handling machine would then transfer the fuel assemblies to the allocated storage channel in the vault, which would then be filled with inert gas and sealed.

The SF assemblies are stored vertically within the channels and cooled by natural circulation. This acts as a self-regulating system in which higher SF temperatures cause increased airflow through the vault, thereby increasing heat removal.

The SF assemblies would need to be prepared for transport to and disposal in a GDF by removal from the store into another container which would be suitable for transport and acceptable for disposal. The KBS-3 container as described in section 10.5.2.4 below is such a container.

10.5.2.4 KBS-3 Container

The reference conceptual design assumption for spent UK PWR fuel is that it is packaged for disposal in a KBS-3V type container, as used by SKB in Sweden [Ref-40]. This is considered to be a viable option for UK ABWR SF with suitable modifications to take account of the different SF assembly dimensions and other characteristics.

For PWR SF use of this concept is currently subject to the assumed temperature constraint applied to the inner bentonite buffer surface within the GDF and that a canister contains four SF assemblies. If all the UK ABWR SF were to be subject to the maximum burn-up considered, which is 60 GWd/tU, then the SF might need minimum 140 years of cooling in interim storage before it could be disposed of in a GDF. This aspect will be discussed with RWM during the disposability assessment for the generic UK ABWR (see Section 13). It is likely that a more realistic case for cooling time would be developed which may include (for example) a mixture of SF assemblies within a single container whose burn-ups would not all be at the stated maximum.

The KBS-3 container may be used for disposal of SF assemblies after a period of interim storage in any one of the storage systems described in this Section: cask, MPC, modular vault dry storage and on-site fuel interim storage pool. Hence, use of the KBS-3 container is considered to be a viable option, subject to the RWM disposability assessment.

10.5.2.5 On-Site Fuel Pool Option

On-site fuel pool storage within an independent building is a method used in many countries for storing spent fuel that has been stored in the SFP in the R/B. The advantages are that cooling performance is high and the condition of the spent fuel can be confirmed by visual inspection from above the water, which will provide the necessary shielding. A disadvantage is that the system requires constant monitoring and operator intervention.

After the period of storage for cooling in the SFP in the Reactor Building, the spent fuel would be transferred to a separate on-site fuel pool in a transport cask. The spent fuel assemblies would need to be prepared for transport to and disposal in a GDF by removal from the pool into another container for transport and the package would be made acceptable for disposal. The KBS-3 container described in section 10.5.2.4 is such a container.

The use of this option will require cooling and clean-up equipment for managing the SF pool water quality.

10.5.3 Spent Fuel Management Options

The SF management options presented in this section have been considered during the GDA process. Subsequent optioneering assessments to select a preferred option (Section 10.8) and the commencement of conceptual design studies of waste management facilities capable of delivering the preferred waste treatment and disposal options (Section 11.6) have been carried out.

The management options are presented in Figure 10.5.3-1 below with additional details given in the accompanying notes.

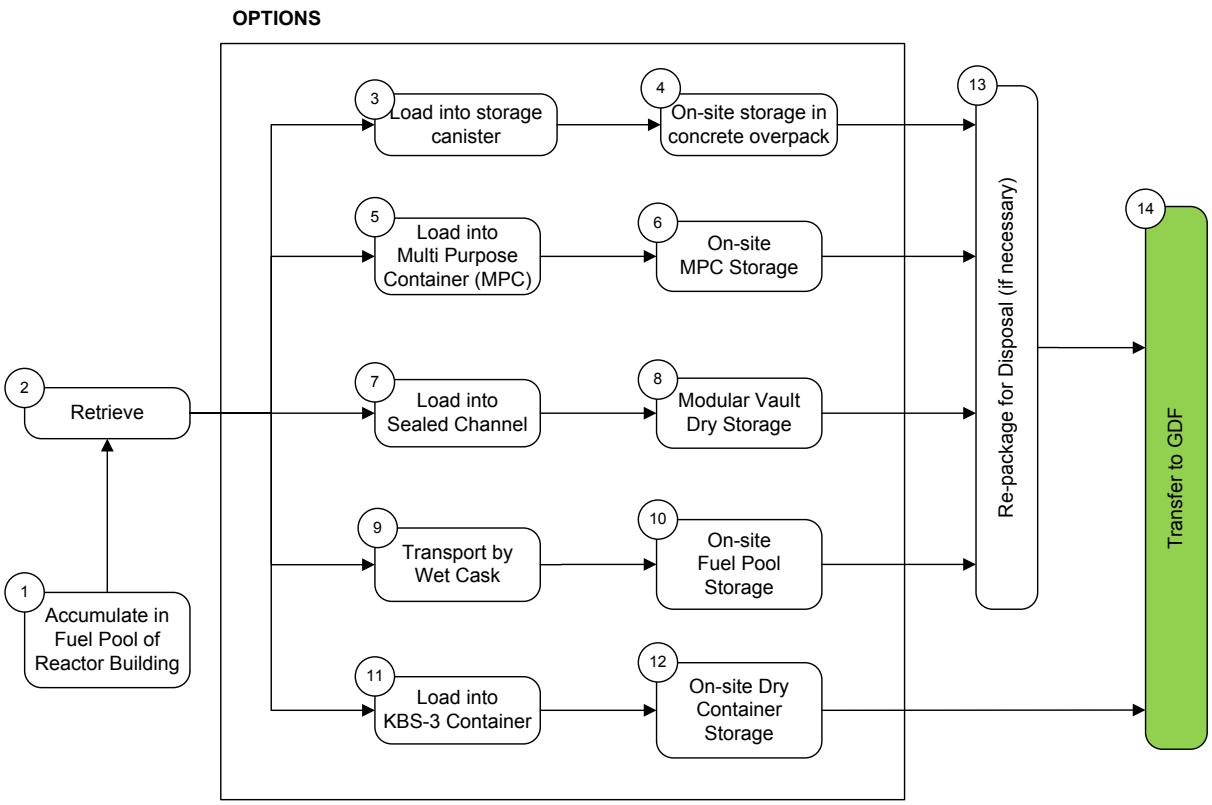


Figure 10.5.3-1: SF Management Options

Notes for Figure 10.5.3-1: SF management options

1. After discharge from the reactor the spent fuel assemblies (each comprising the fuel bundle and its surrounding fuel channel) are accumulated in the SFP for a period of decay storage to allow them to cool. This period is 10 years for typical BWR spent fuel and the SFP water is conditioned to maintain the correct temperature, cleanliness and chemistry conditions.
2. The method used for retrieval of the spent fuel/fuel channel depends upon the subsequent storage option chosen. The usual method for removal of the spent fuel assemblies is to load them vertically into a cask which is submerged into the SFP, followed by lidding and removal of the cask. Operations to decontaminate the cask exterior and condition the internal water are also undertaken prior to transport of the cask to its intended location. This is usually a reprocessing facility but for the UK ABWR spent fuel reprocessing is not assumed and hence the retrieval method is likely to be different. The envisaged retrieval method, as part of each of the noted options is described in the relevant sections below.
3. Loading the spent fuel assemblies into a dry storage system requires a number of steps which include the following:
   a. Load the spent fuel assemblies, under water, into a metal canister, which is compatible with the chosen concrete storage overpack. This canister may be an MPC, as described in 5 below.
   b. Drain the water from the canister and seal with a lid closure. This would be completed in a facility which provides appropriate shielding, containment for contamination control and remotely operated equipment.
   c. Dry the internal environment and backfill with an inert gas.
   d. Transfer the canister into a concrete storage overpack.
4. The canisters in overpacks are stored in a suitable facility which is likely to be similar to an industrial type warehouse which provides weather and security protection. The canisters are likely to be transported between the SFP and the storage facility in transfer casks. Loading into overpacks and movement to and from the storage position will require specialist heavy equipment. It is unlikely that the store will require any conditioning of the internal environment as the storage overpacks can be inspected externally and any necessary maintenance undertaken.
5. Use of a Multi-Purpose Container (MPC) similar to the type supplied by Holtec may allow the spent fuel assemblies within to be disposed of directly to a GDF without further repackaging. This would be subject to granting of an LoC, which will include a disposability assessment from RWM and other decisions related to logistics and commercial/business requirements. For example, a container suitable for GDF disposal is likely to be manufactured from relatively expensive materials and to more stringent requirements than required for a period of on-site interim storage inside an overpack. This could entail greater costs at this stage than if packaging for disposal was delayed until a GDF was available. The time period from the start of spent fuel interim storage to the availability of a GDF may also allow for the development of, as yet unknown, more cost effective techniques for producing a disposable package. Or the requirements for disposability at the GDF may have been modified to allow for a more cost effective method of spent fuel packaging to be used. These potential benefits would need to be weighed against the requirements for repackaging of the spent fuel, when the GDF was available, assuming that an MPC was not initially used.
6. Storage of the MPC would be within a suitable concrete overpack in facilities as described in 4 above.
7. The spent fuel assemblies may be transferred into sealed channels, either singly or in groups after being removed from the SFP and dried. The sealed channels would be part of a Modular Vault Dry Store (MVDS) facility. The operations to remove, dry and transport the assemblies to the MVDS would require specialist equipment, probably remotely operated within a shielded containment facility

and utilising a shielded transport vehicle to transfer the assemblies from the reactor building to the, probably separate, MVDS building.

8. Interim storage within an MVDS system can continue until a GDF is available as the cooling is by passive means, which increases its reliability.
9. Use of a wet cask for removal of the spent fuel assemblies, as described in 2 above, will facilitate the transport of the assemblies to an on-site fuel pool storage facility, which would be separate from the reactor's operational SFP.
10. Fuel pool storage would continue for an extended period until a GDF was available. This would include separate facilities for conditioning, cooling and cleaning the water to maintain the correct quality.
11. The KBS-3 container is a developed disposal package which may be suitable for disposal to a GDF, subject to granting of a LoC by RWM. Hence, the spent fuel assemblies may be loaded directly into these containers using a procedure similar to that described in 3 above. However, as these containers are likely to be more expensive than those used for interim storage only, their use will need to be carefully considered taking account of factors such as discussed in 5 above. Use of these containers may also eliminate the opportunity of utilising any improved methods or take account of any changes in the Regulatory and disposability regimes during the interim storage period. KBS-3 disposal packages are not designed as interim storage containers.
12. The KBS-3 containers would be stored during the interim period within a suitable overpack in facilities as described in 4 above.
13. Where appropriate, the spent fuel assemblies need to be re-packaged for transport to and disposal at the GDF. As described in notes 5/6 &11/12 above, where the assemblies are initially stored in an MPC or the KBS-3 container, they may be acceptable for disposal subject to granting of an LoC by RWM. Hence, re-packaging may not be required for these options.

    For options 3/4 and 7/8, where the spent fuel assemblies have been stored for the interim period in dry facilities, re-packaging by transfer into a suitable disposal container requires a suitable facility which incorporates shielding and containment for contamination control and remotely operated equipment.

    For options 9/10 above, transfer into a suitable disposal container requires similar facilities as above plus draining and drying facilities to ensure that the spent fuel assemblies contain moisture below the limits required by the safety case prior to loading into a suitable disposal container.

    These latter options require the granting of appropriate LoCs by RWM prior to re-packaging for disposal.

    A suitably contained and shielded facility for the inspection and potential rework of casks is required following the removal from use of the cooling pools during decommissioning. This cask inspection facility may also be used for re-packaging prior to disposal at the GDF.
14. Transfer of the packaged spent fuel assemblies to a GDF will be subject to granting of the appropriate LoCs, as described above. Depending upon the packaging adopted for disposal a suitable transport method will need to be adopted. For example, the Holtec system referenced above includes various transport casks. However, within the UK the use of these or any other transport cask will need to be assessed by the appropriate authority as well as the noted requirement for LoCs. The ONR currently covers Nuclear Transport aspects within their remit under its Radioactive Materials Transport function.

10.6 Non-aqueous Liquid Radioactive Waste

The document, Guidance on the scope of and exemptions from the radioactive substances legislation in the UK [Ref-41] considers 'relevant liquid' and states the following:

The legislation defines 'relevant liquid' as a non-aqueous liquid, and certain types of aqueous liquid with specified hazardous properties. The purpose of this definition is to allow such liquids to be treated, for the purposes of this legislation, as a solid because the exposure pathways are the same as those for solids.

There are certain liquids – for instance mercury and oils – for which the drinking water pathway equally can be ruled out, not least because other pollution control legislation does not allow disposals to the water environment. This legislation therefore … assumes that the disposal of such materials is to a conventional 'solid' waste route; that is, not disposed of to drains, sewers, open water or groundwater.

Following this reasoning, the management of non-aqueous liquid wastes such as oil and grease is considered in this solid waste strategy document. Free non-aqueous liquids and solid wastes contaminated with such liquids are also considered.

It is assumed that the site aqueous liquid waste systems susceptible to oil contamination will include adequate installations, such as oil interceptors, to segregate organic, non-aqueous contaminants from the aqueous wastes. If the separated organic fraction has potential for radiological contamination then it will be identified and handed over to the non-aqueous liquid radioactive waste stream. The strategy described in this note does not consider any aqueous liquid except small residual volumes that may accompany, and be treated as a part of, separated oils.

The case that radioactive oils will not present a significant volume of waste is presented in [Ref-42]. This reference illustrates optimisation of design to minimise waste. However, it is reasonable to expect that during normal operations some potentially radioactive contaminated non-aqueous liquid or non-aqueous liquid contaminated wastes will be generated through, for example, the following operations:

- Maintenance of pumps,
- Maintenance of hydraulic equipment,

This strategy holds the following assumptions for normal operation:

- The volume of free non-aqueous liquid radioactive waste generated per annum will be low,
- The quantity of non-aqueous liquid contaminated solids will be low,
- The specific radioactivity of the wastes will be low, with a maximum waste classification of LLW,
- The non-aqueous liquid wastes will require characterisation appropriate to their identified likely waste route; exempt material, VLLW, LLW.
- Low throughput, low radioactivity non-aqueous liquid wastes may be passed through the site solid LLW facility before consignment off site.

The following sections describe expected wastes from normal operations and the Hitachi-GE strategy for their treatment and disposal.

10.6.1 Potentially Contaminated Non-aqueous Liquid Waste

Guidance on exemption and clearance of radioactive substances [Ref-41] and [Ref-43] provide definitions of 3 categories:

- 'Clean' substances that are **'Out of scope' of regulatory requirement**;

- Radioactive substances conditionally **exempted from the requirement for a permit under the legislation**;
- Radioactive substances that require a permit.

This section is not concerned with 'clean' waste but does consider waste that is potentially contaminated which, through sampling and characterisation, may be demonstrated to be of sufficiently low radioactivity to be out of scope of regulatory requirement.

10.6.1.1 Waste Source

The possible sources of waste described below are indicative examples and are not an exhaustive list of potential arisings. Sources of free liquid wastes may include:

- Lubrication and hydraulic oils removed or spilled during maintenance of equipment where there has been potential or known contact with contaminated equipment, fluid or surfaces;
- Separated oil from an active aqueous waste stream;
- Separated oil from an inactive aqueous waste stream if the source of the oil cannot be identified or is suspected to have originated from within a controlled area (includes run-off).

Oil contaminated solids may include:

- Soft wastes (rags, wipes, vinyl sheeting, clothing, Personal Protective Equipment (PPE)) produced during maintenance of plant or equipment;
- Spill clean-up wastes (absorbent granules, absorbent bunds / blankets, soft wastes);
- Plant or equipment items that have previously contained oil.

10.6.1.2 Waste Segregation

Wastes comprising non-aqueous liquids, whether free or as surface contamination, will be segregated at source and packaged appropriately; in plastic bottles or kegs for liquids, in poly bags for contaminated solids. The packages will be double contained for movement and clearly identified following site waste management procedures and information system.

Segregation is necessary to maintain as far as practicable a simple and stable waste form; avoiding chemical contamination to, and radiological contamination from, other wastes. Oily wastes will be identified to bypass any potential compaction steps in the LLW processing system.

10.6.1.3 Characterisation

The characterisation requirements to demonstrate that a waste is exempt from legislative control are described in reference documents [Ref-41] and [Ref-43]. Representative samples of the non-aqueous liquid waste will be collected as close to the source as practicable to enable timely measurement and characterisation, minimising the time from arising to removal from site.

10.6.1.4 Treatment and Disposal

Following characterisation the waste will either be shown to be out of scope from regulatory requirement or to contain sufficient radioactivity to be classed as VLLW (or potentially LLW) and will be handled accordingly:

Out of scope liquid waste will be consigned to a conventional waste route that, depending on chemical composition and condition will be disposed of by a specialist contractor following the principles of the waste hierarchy:

- Re-use or recycling where practicable, or
- Incineration (with energy recovery where practicable)

Out of scope soft wastes contaminated with oil will be incinerated in a facility with energy recovery where practicable.

Oil contaminated items demonstrated to be out of scope will be wiped clean of oil; the wipes following the incineration route above as conventional waste and the solid item being disposed following an appropriate conventional solid waste route.

10.6.2 VLLW and LLW Non-aqueous Liquid Waste

Non-aqueous liquid and non-aqueous liquid contaminated wastes that either cannot be shown to be out of legislative scope for radioactive waste or that demonstrate specific activities within the VLLW and LLW range (described in sections 10.4.1 & 10.4.2) are managed through the following process.

10.6.2.1 Waste Source

The potential sources of waste are similar to those identified in 10.6.1.1; however, in this case either the waste is known to be and / or measured to be contaminated to a specific radioactivity above that calculated for exempt waste.

Liquid scintillation counting sources prepared during radioactive sample analysis typically contain water miscible organic scintillation cocktail. The volume and specific radioactivity of such sources is low and disposal of such waste is typically via a suitable waste water stream. The site ‘hot lab’ where radioactive counting sources may be prepared is connected to the HCW system which is considered suitable.

In the unlikely event that water immiscible organic scintillation cocktail is used the sources will be segregated in the laboratory and treated as LLW non-aqueous combustible waste.

10.6.2.2 Waste Segregation

As previously noted, waste segregation will be at source and waste will be packaged appropriately and labelled in accordance with site procedures.

Oily wastes will be identified to bypass any potential compaction steps in the LLW processing system.

10.6.2.3 Characterisation

The characterisation requirements are to provide a sound basis for BAT decisions and demonstrate compliance with LLWR waste acceptance criteria (WAC) [Ref-25] or other suitably permitted disposal facility. Representative samples of the non-aqueous liquid waste will be collected as close to the source as practicable to enable timely measurement and characterisation, as well as to minimise the need to re-open waste packages in downstream facilities. This demonstrates BAT through early data collection, ensuring that dose uptake is ALARA and reducing the likelihood of accidental spillage by minimising onward handling.

10.6.2.4 Treatment and disposal

As noted in sections 10.4.2 and 10.8.1, VLLW and LLW disposals may be managed through the LLWR Waste Services Contract (WSC) or directly with another suitably permitted disposal facility.

Non-aqueous VLLW and LLW liquid wastes will be processed in the following ways:

- Oil contaminated wastes such as rags, vinyl or clothing will be treated as miscellaneous combustible solid waste and consigned for incineration. They will not be compacted at site.
- Oil contaminated non-combustible items will be wiped clean and the waste segregated such that the rags are treated as above and the item is assigned to an appropriate waste route.
- Small volumes of free non-aqueous liquid waste will be packaged in appropriate kegs at source and consigned for incineration.

10.7 Summary of Management Options

The available management options, as identified during GDA and presented in sections 10.4.3, 10.4.5 and 10.5.3 for each waste category and SF, are summarised in Table 10.7-1 below. These options are based upon existing practices within the UK for legacy sites (e.g. Magnox, Sellafield, Dounreay) and some operational sites (e.g. Sizewell B) and from international experience, especially for the management of SF. The options are considered to represent BAT because of their current applications, as noted above.

Optioneering assessments to select a preferred option (Section 10.8) and the commencement of conceptual design studies of waste management facilities capable of delivering the preferred waste treatment and disposal options (Section 11.6) have been carried out.

Table 10.7-1: Summary of Waste and Spent Fuel Streams and their Management Options

No.	Title	Category	Form	Management options
1	Dry active waste	VLLW	Solid	Recycle metals where practicable, compaction, where possible and direct disposal of remainder to permitted disposal site.
2	HVAC Filters	LLW	Solid	Depending upon filter construction and use: incineration (with or without compaction) or supercompaction and direct disposal to the LLWR.
3	Bead resin	LLW (Identified as borderline waste, see 10.4.6)	Wet	Solidify with polymer or cement formulation in disposal container.
4	Concentrates	LLW	Wet	Solidify with cement formulation in disposal container, typically THISO or 210 litre drum.
5	Miscellaneous combustible	LLW	Solid	• Incineration (off site) • Compaction within a drum (except for non-aqueous contaminated liquid wastes)
6	Miscellaneous non-combustible	LLW	Solid	• Size reduce • In-drum grouting

No.	Title	Category	Form	Management options
				• Compaction within a drum
7	Sludge (crud)	ILW	Wet	• Dry and store within robust shielded container • Encapsulate in cement formulation • Encapsulate in polymer formulation
8	Powder resin (includes decommissioning resin from system decontamination)	ILW	Wet	• Dry and store within robust shielded container • Encapsulate in cement formulation • Encapsulate in polymer formulation
9	Higher activity metals – control rods	HLW at arising, ILW at disposal	Solid	Store on site in SFP and dry shielded facility, followed by size reduction and: • Place in disposal container (typically 3 m^3 box) and grout with cement formulation • Fuel Channels stay with SF
10	Higher activity metals – fuel channels	HLW at arising and remains with SF.	Solid	
11	Higher activity metals – others	HLW at arising, ILW at disposal	Solid	
12	Contaminated and irradiated metal and concrete (from decommissioning)	LLW	Solid	• Decontamination as appropriate • Recycle metals where practicable • Size reduce • Compaction within a drum where practicable • Cement grout and direct disposal to permitted facility
13	Irradiated metal (from decommissioning)	ILW	Solid	• Size reduction (if necessary) • Condition in final disposal container (e.g. 3m^3 box) • Store in ILWS pending GDF availability
14	Irradiated metal (RIN & RPV)	HLW at arising, ILW at disposal	Solid	Decay store on site in SFP and HLW Decay Store, followed by: Size reduction, segregation as necessary, loading into disposal containers (3m^3 box) and dispatch to the GDF.

No.	Title	Category	Form	Management options
15	Spent Fuel	Used fuel elements	Solid	• Canister and overpack storage with future packaging for disposal • Multi-Purpose Container storage for future disposal without repackaging • Dry vault storage (Modular Vault Dry Store) followed by packaging for disposal. • Extended storage in on-site interim storage fuel pool followed by packaging for disposal.

10.8 Preferred Options Selected for GDA

10.8.1 Waste Management

An optioneering study [Ref-35] has selected the preferred waste management option for each identified waste stream to be taken forward in the development of the GDA submission. The conclusions are as follows.

For Solid LLW:

- HVAC filters to be transferred off-site to a suitably permitted LLW incinerator. Any filters unsuitable for incineration will be supercompacted and disposed of at the LLWR.
- Combustibles to be transferred off-site to a suitably permitted LLW incinerator.
- Recyclable metals to be transferred off-site to an appropriate metal melting facility.
- Non-compactable and non-recyclable materials (including grouted waste) to be sentenced for direct disposal to the LLWR in an approved transport container.

For Wet LLW:

- The preferred technique for the management of wet LLW (resins, concentrated liquid wastes, and activated carbon) is cement immobilisation. This option would also include a pre-processing alkaline-swelling step for the LLW resins. In-line mixing of waste and cement into THISO is considered preferential to in-drum mixing techniques where practicable as it makes more efficient use of the available disposal volume.
- The bead resin has been identified as cross-boundary LLW / ILW. The options for decay storage in tanks prior to processing or cementation within 210 litre drums for higher radioactivity range resin batches and subsequent decay storage prior to consignment to the LLWR are discussed in section 10.4.6. The preferred option in GDA, and underpinning PCSR Chapter 18, is decay storage in the bead resin storage tanks (SS system) in the RW/B.
- The GAC has the potential for relatively high chloride concentrations that render it unsuitable for conditioning directly into a THISO. In-drum cementation is preferred for this low volume waste stream.
- The solidified waste is to be consigned for direct disposal at the LLWR.

For Solid HAW from operations (HLW at arising, ILW at disposal):

- The current concept for reactor arising solid HLW is decay storage in the SFP followed by dry interim storage in a canister and overpack system (casks) on-site prior to repackaging and subsequent disposal to GDF as ILW [Ref-7] section 18.10, [Ref-35]. The reactor operational HAW consists of the following;
    - Control rods
    - Local Power Range Monitors (LPRMs)
    - Start-up Range Neutron Monitors (SRNMs)
    - Traversing In-core Probes (TIPs)
    - Neutron Source Units (NSUs).
- The waste is to be retrieved from the HLW decay store, size reduced (if necessary) and packaged for final disposal in an appropriate container, pending final disposal to the GDF;
- The standard 3 m^3 box, currently used by many legacy sites in the UK, is recommended as the packaging/disposal container.

For Solid HAW from decommissioning:

- Decommissioning activated solids such as RPV sections and reactor internal components will be decayed as appropriate to ensure dose uptake is ALARA, size reduced, packaged and stored pending final disposal to the GDF. Package choice will depend on characterisation and segregation at arising. The HLW will be packaged and stored in casks (canister and overpack) as for operational HLW. The ILW may be packaged directly into a final disposal container (or other appropriate container if anticipated to be repackaged at a future date following decay). ILW estimated to remain as ILW following decay storage awaiting GDF availability may be conditioned in the disposal package as soon after arising as practicable. Any LLW from segregation will be treated and packaged for disposal;
- Decommissioning ILW contaminated solids to be decontaminated (if BAT to do so), size reduced where necessary and packaged into an appropriate disposal container such as a 3m^3 box which is suitable for grout immobilisation (on-site). The waste to be stored in the ILWS, pending final disposal to the GDF; and
- The ILWS and HLW store to comprise areas designated for decay storage until sufficient decay has taken place to enable processing, transport, and storage.

For Wet ILW:

- The preferred technique for the management of wet ILW (resins and crud) is cement immobilisation, storage and disposal.
- The standard 3 m^3 drum, currently used by many legacy sites in the UK, is recommended as the packaging/disposal container.
- It was recommended that some development work will need to be undertaken to optimise the wasteform cement formulation, and that there is a proviso that the BAT assessment be reviewed and updated once an appropriate development programme has been completed.

For the ILW streams it is noted that the above options have been proposed to be assessed for disposability by RWM.

10.8.2 Spent Fuel Management

The management options for SF have been assessed during GDA and are presented in the High Level Optioneering on Spent Fuel Interim Storage report [Ref-44].

The optioneering scoring demonstrated conclusively that a concrete overpack system is the best available

approach for spent fuel interim storage for the UK. The concrete overpack solution is a proven option used in the U.S. and includes the following steps:

- Initial cooling of the SF in the SFP (10 years);
- Loading of SF into canisters, drying and backfilling;
- Transfer of the SF canister to a concrete overpack;
- Storage within the concrete overpack (the sealed SF canister may be transferred to a new concrete overpack if storage requirements pass the useable life of the overpack);
- Transfer of the SF canister to a final disposal package;
- Disposal to the GDF.

10.9 Solid Waste Management during Decommissioning

The decommissioning strategy of the UK ABWR is described in PCSR chapter 31: Decommissioning [Ref-11] and the Decommissioning Waste Management Topic Report [Ref-17]. The proposed baseline decommissioning strategy for the UK ABWR is prompt decommissioning where possible. The decommissioning phase for the main buildings, currently planned to follow the 'prompt decommissioning' strategy with immediate removal of the fuel, would require a predicted period of approximately 30 years for completion. The following decommissioning phases are considered:

- Phase 1: Before end of generation (Pre-closure preparatory work);
- Phase 2: Immediately after end of generation (SF management, Post Operational Clean Out (POCO) and system decontamination);
- Phase 3: Power Plant Decommissioning (dismantling and decontamination of plant, demolition and delicensing);
- Phase 4: SF, HLW & ILW storage period;
- Phase 5: HLW / ILW store emptying, repackaging and disposal;
- Phase 6: Spent Fuel storage, SFIS emptying, repackaging and disposal;
- Phase 7: Demolition and delicensing of the site.

The proposed waste management strategies presented in this document are considered valid for decommissioning wastes. The early characterisation of potential decommissioning wastes through operational experience of other NPPs and calculations based on history and usage is very important to confirm and define wastes ahead of the decommissioning phase. Effective early characterisation will reduce uncertainty in hazard identification, the programme and cost of dismantling.

The decommissioning waste inventory is detailed in Appendix A, Tables A0-1 to A2.8-2.

The following sections present an overview of the decommissioning tasks planned for each phase. Important steps within the evolution of the solid waste management system are noted and expanded upon where they may be considered as an addition to the system, a subtraction from the system or manage waste types that did not routinely arise during operations. These steps include:

- The construction and commissioning of a Decommissioning Waste Management facility in Phase 2.
- The construction and commissioning of a Hot Cell for SF/HAW inspection and repackaging in Phase 2.
- System chemical decontamination in Phase 2.
- The treatment of the RIN and RPV in Phase 3.

- The decommissioning of the SFP and Rw/B in Phase 3.
- The solid waste management arrangements following demolition of the main buildings Phases 4 to 7.

10.9.1 Phase 1: Before End of Generation (Pre-closure Preparatory Work)

Preparation for decommissioning will begin during the operational phase of the power station lifecycle. Preparatory works will include:

- Preparation of revisions to waste management plans.
- Initial characterisation and waste inventory preparation based upon design and inventory records, operational parameters and experience. Measurements will be made where safe and demonstrably BAT to do so.
- Preparation for regulatory submissions and environmental permits.
- Preparation for disposal supplier submissions (e.g. as part of the RWM LoC process).
- Preparation and action of fuel management plans such that the final batches of SF removed from the reactor may be transferred to, and subsequently out of, the SFP in the timescales proposed in the finalised decommissioning programme.

Solid radioactive wastes produced will be managed as for operational solid radioactive waste.

It should be noted that the SFIS facility and the HLW store will be constructed early in the site's operational phase to accommodate SF and HLW storage between export from the R/B following 10 years cooling in the SFP and GDF availability.

10.9.2 Phase 2: Immediately After End of Generation

10.9.2.1 SF Management

The SF is transferred from the reactor to the SFP for 10 years cooling before transfer to the SFIS. The options for SF management are as presented in Section 10.5 and 10.8.2 with the baseline selected option described in Section 11.6.

Following removal from the reactor, control rods and miscellaneous activated components will be managed in the same way as during operations (10.4.4.4, 11.4). Radioactive solid wastes from continued operation of systems such as the LWMS, OG and HVAC as well as miscellaneous solid wastes from routine operations such as maintenance will be managed following existing arrangements from the operational phase.

10.9.2.2 POCO

Prior to deplanting of buildings, systems will be subject to POCO to remove residual mobile waste such as water, oil, demineraliser resin and sludge. Redundant, routinely replaced and readily removed equipment may also be removed from buildings and managed as waste following, for example, routine operations phase maintenance procedures. Since the waste types and POCO operations will be common to the site operational phase it is anticipated that POCO operations will be covered by the operations phase safety case. Similarly, waste management systems and disposal routes will be common to the operations phase.

10.9.2.3 Installation of a Decommissioning Waste Management Facility

The installation of a Decommissioning Waste Management Facility is required to carry out the pre-treatment, treatment, segregation, conditioning and packaging on the various items of solid waste, mainly LLW arising from decommissioning activities in the main buildings.

The Decommissioning Waste Management Facility is expected to process waste in the following ways:

- Receipt and handling of waste items, large or small from the various main building decommissioning work locations.
- Size reduction
  - Items too large to fit into standard waste containers will be size reduced.
- Volume reduction
  - Facilities will be provided to compact waste to reduce its volume in line with the waste hierarchy. The suitability of compaction to reduce the volume of each waste will be decided on a case-by-case basis.
- Decontamination
  - The aim of decontamination is to reduce the activity associated with waste items, to reduce dose to workers during decommissioning and to reduce the amount of higher category waste and hence the cost of disposal. However, the benefits of the decontamination need to be balanced against other factors such as secondary wastes generated and dose to workers during the decontamination process itself.
- The capability to contain and manage all gaseous, liquid and solid decontamination secondary waste.
- Monitoring and characterisation to enable segregation and the management of waste in accordance with the waste hierarchy.
- Receipt and management of new, empty waste packages.
- Packaging of waste.
- Management of the waste transfer rate to the SWF.

The Decommissioning Waste Management Facility will be a new facility and the main consigning facility to the SWF.

There is an opportunity to re-use the deplanted T/B as the Decommissioning Waste Management Facility. The final decision whether to construct a new facility or to install the facility in the T/B will be made by the future site operator based upon BAT considerations and site specific constraints and opportunities.

The wet and dry solid wastes resulting from POCO of any redundant radioactive systems will be managed in the same way as the equivalent waste that arose during the operational phase.

10.9.2.4 Construction of a Hot Cell for SF Inspection and Repackaging of Buffer Stored ILW

A facility to carry out the inspection of SF and the repackaging of buffer stored ILW is required prior to the removal from service of the SFP in Phase 3.

10.9.2.5 System Decontamination

Decontamination techniques employed at decommissioning require high efficiency and minimisation of secondary wastes to be considered BAT and include system chemical decontamination: Decontamination within systems to reduce the radiation exposure of workers to ALARA and to prevent the spread of contamination during subsequent dismantling operations.

The RPV, CUW and RHR systems will undergo full system chemical decontamination and it is planned to utilise a chemical oxidation reduction technique. Examples of such methods are given in Table 10.9.2-1.

Table 10.9.2-1: Chemical System Decontamination Techniques

	Decontamination	Removal target	DF	Secondary	Temperature of

	method	Soft crud (iron oxide)	Hard crud (chromium oxide)	Base metal		waste volume	decontamination liquid
Oxidation-reduction dissolution decontamination method	CORD*[1]	X	X		10-100	Very small	90°C
	HOP*[2]	X	X		10-100	Very small	90°C
	T-OZON*[3]	X	X		10-100	Very small	90°C
	DfD*[4]	X	X	X	100	Small	90°C

*1: Chemical Oxidation Reduction Decontamination method (AREVA tech.)

*2: Hydrazine, Oxalic Acid and Potassium Permanganate method (Hitachi-GE nuclear energy tech.)

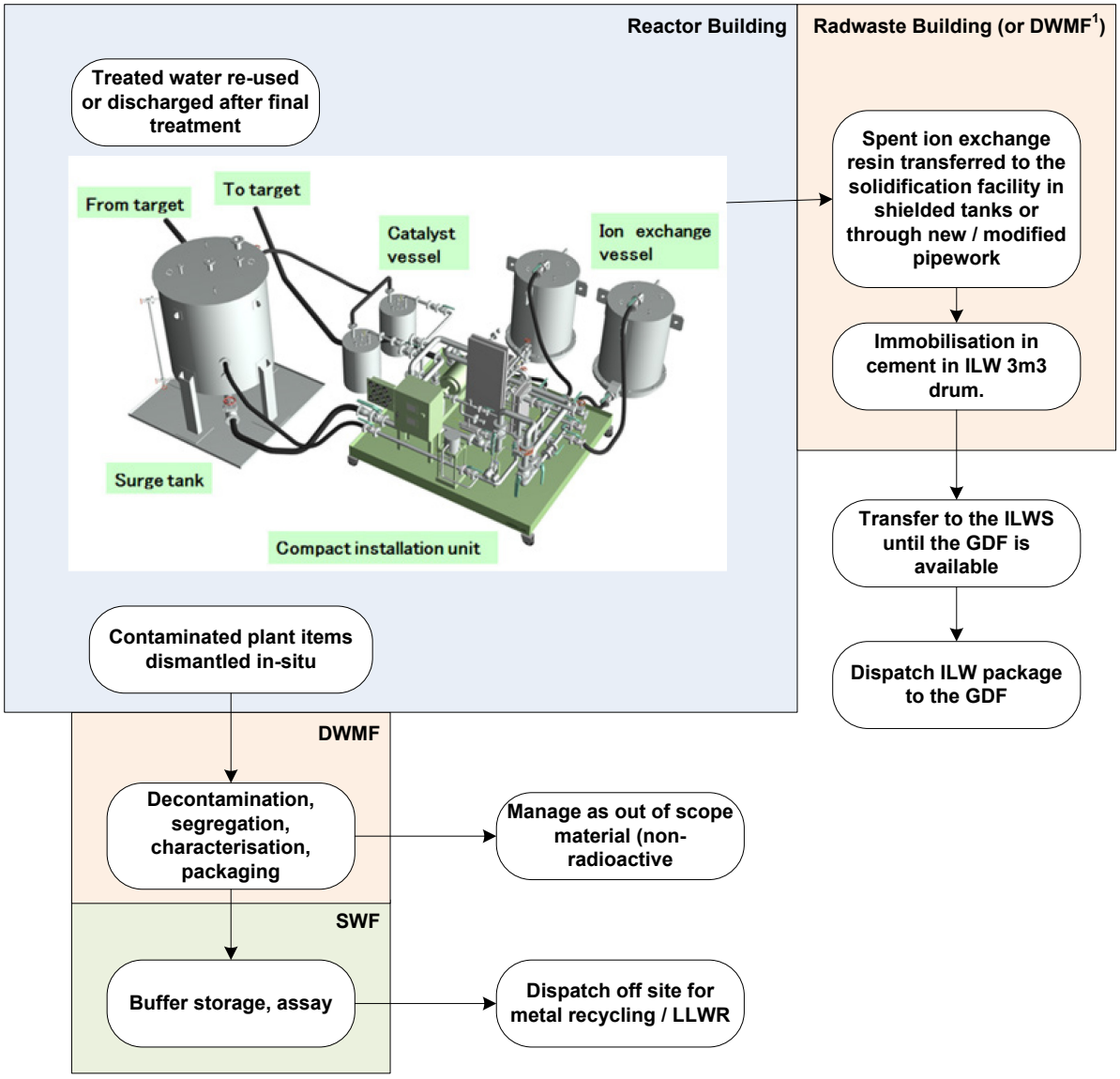
*3: Toshiba Ozone Oxidising Decontamination for Nuclear Power Plants method (Toshiba tech.)

*4: Decontamination for Decommissioning method (EPRI tech.)

The final choice will be made by the future site operator and will be demonstrably BAT.

Following the chemical decontamination process, the system may be dismantled, with some components further decontaminated in dedicated areas as appropriate to their size, form, composition and residual contamination.

Figure 10.9.2-1 illustrates how the secondary wastes arising from the system decontamination plant may be managed through the existing radioactive waste facilities.



[1]The baseline assumption is that the existing, modified ILW solidification facility in the Rw/B will be used to process the ILW resin.

Figure 10.9.2-1: An Example of Waste Management From a Decontamination Installation

10.9.3 Phase 3: Power Plant Decommissioning

10.9.3.1 T/B Dismantling and Deplanting

After power generation has ceased, the turbine system will be redundant. The turbines and associated plant and equipment that have been in contact in with the coolant will be dismantled, decontaminated, characterised, segregated, size reduced and packaged in-situ or within designated areas of the T/B.

The management options for the dry solid LLW are as presented in Section 10.4 and the baseline selected option for management of the packaged waste is described in Section 11.1.

Solid radioactive waste generated during dismantling and deplanting of the T/B is expected to be categorised as LLW or below. The management options for the dry solid LLW are as presented in Section 10.4 and the baseline selected option for management of the packaged waste is described in Section 11.1.

The overall LLW waste management strategy is unchanged to that for operations. The items of plant housed within the T/B are large and require decontamination, size reduction and segregation in-situ or, at least, within the T/B itself. The T/B is well suited to the treatment of wastes: available space following export of non-radioactive items, radiological control and protection systems already installed to support operations; transfer and export arrangements for large items during operations maintenance and export of non-radioactive large items at decommissioning may potentially be re-used.

Off-site waste disposal routes for large metallic radioactive waste items may include:

- Metal treatment, segregation and recycling;
- Metal melt (waste volume reduction) with segregation and recycling where practicable (currently this solution requires international transport), and;
- Direct disposal to a LLW facility if the above options are not practicable.

The final disposal solutions will be determined by the future operator following consideration of waste measurement and characterisation as well as the waste treatment and disposal market at the time. The selected option will be optimised by being demonstrably BAT.

10.9.3.2 Treatment of RIN and RPV

The RPV and RIN are shown in Figure 10.9.3-1. The RPV and RIN are metal and will have become significantly activated during the reactor's operation. The activation throughout the RPV and RIN will not be uniform, with the RIN and RPV sections closest and least shielded from the reactor core's neutron flux being the most activated. The Core plate, Upper Grid Plate (Top Guide), Fuel Support Parts, and Control Rod guide tube are expected to be the most activated internal components and HLW at arising, cooling to ILW prior to disposal to the GDF.

The RWM disposability assessment (see section 13.2) has indicated that $3m^3$ ILW boxes would be the preferred final waste package for the RIN and RPV ILW. The final package selection will be determined by the waste characteristics at decommissioning, BAT selection and application of the LoC process by the future site operator.

The radioactive waste inventory presented in the GDA, and underpinning the waste management strategy, is expected to prove pessimistic. The future licensee should recalculate the activated metal waste inventory once the reactor construction materials are finalised.

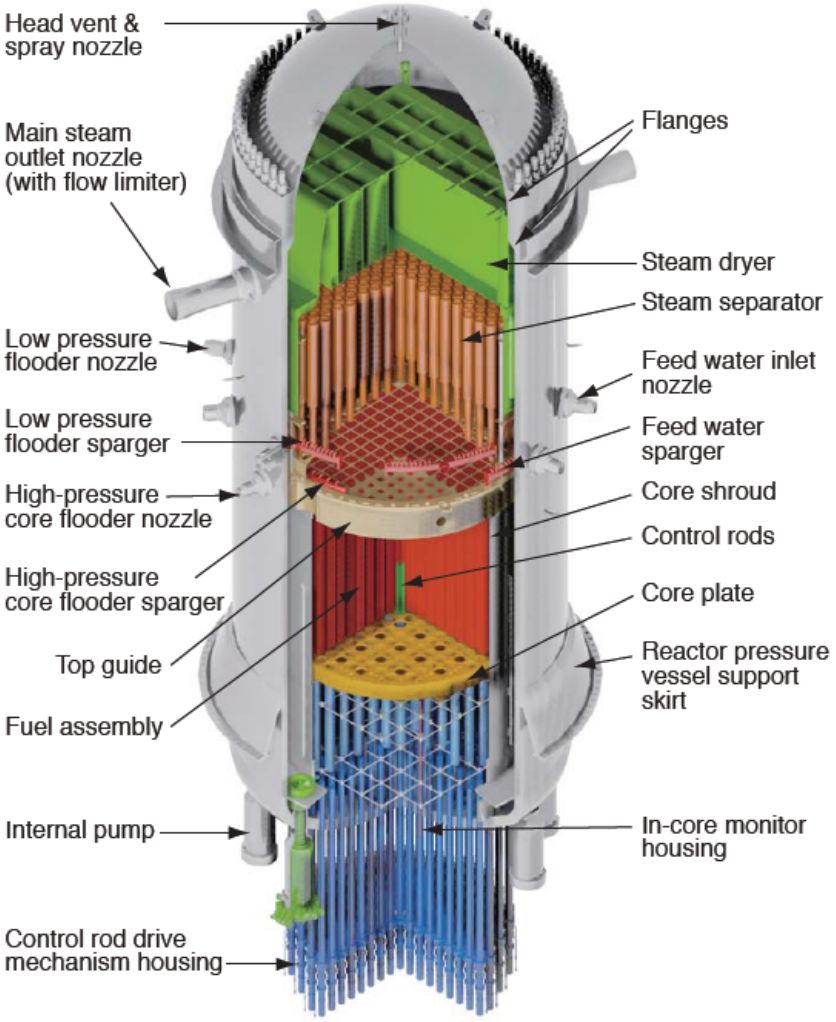


Figure 10.9.3-1: ABWR Reactor Pressure Vessel and Internals

RIN

The RIN dose rates and potential for contamination require that they are handled and treated remotely and under water. The RIN are expected to comprise LLW, ILW and HLW at arising. Characterisation and segregation will be applied as far as practicable, subject to future operator BAT and ALARP assessment, to the waste as it arises.

The HLW RIN at arising will be size reduced and managed as for HLW control rods and activated components during operation (10.4.4.4, 11.4), including decay storage in a canister and overpack system between export from the R/B and availability of the GDF. Characterisation, segregation and repackaging to final disposal containers will be carried out in the repackaging facility (see Figure 11.4.1-1) which may potentially be incorporated into the Hot Cell.

The majority of the RIN inventory is estimated to be ILW at arising. The RIN ILW will be subject to radioactive decay in the period between retrieval and disposal to the GDF. Some of the ILW could have the potential to decay to radioactivity levels allowing recategorisation as LLW. At the GDA stage there is great uncertainty when considering the effectiveness of waste segregation at arising. The option exists to measure and segregate the ILW (and LLW following decay) waste when the GDF becomes available, potentially

benefitting from reduced dose rates. The future licensee should select the characterisation and segregation options BAT and ALARP at the time with consideration of characterisation data, segmentation containment constraints, GDF availability updates, interim decay storage package options, and waste strategy.

The baseline RIN management strategy presented proposes buffer decay storage of ILW followed by characterisation, segregation and repackaging. The use of 3m^3 boxes and / or NFWC and overpacks followed by repackaging at the time of being sent to GDF provides an achievable solution however, it is recognised that it may not be optimal in terms of BAT and ALARP at the time of decommissioning. The potential to use alternative ILW storage packages, or to package ILW immediately for disposal, remains open to the future operator subject to the application of BAT and ALARP.

RIN that is demonstrated to be LLW at retrieval will be segregated, subject to BAT and ALARP assessment, and routed to the Decommissioning Waste Management Facility for management as LLW.

The dose rates and potential for contamination dispersion require that the activated RIN are handled and treated remotely under water. The RIN will be freed from the RPV, transferred to the cutting pool and segmented under water. It is anticipated that the DSP will be used to contain the cutting pool.

In summary, the proposed management strategy for RIN given in [Ref-17], [Ref-11] and this arrangements document presents an achievable management solution that has the potential to be demonstrated BAT. It does not foreclose other options or variations available to the future site operator that may be shown to be BAT and ALARP based upon their inputs and assessments at the time.

RPV

It is proposed that the RPV head is segmented under water, potentially utilising the infrastructure installed for RIN segmentation, however the final option selection will benefit from further development once detailed information on its radiological characteristics are known.

Following treatment and export of the RIN, the DSP will be drained and decontaminated to enable the manual installation of a size reduction containment in the dry DSP. The retained water level in the RPV will be lowered as the RPV is segmented to enable remote cutting in air above the water level. The RPV segments will be transferred to the DSP for further size reduction, characterisation and segregation as required.

The RPV is expected to comprise volumes of LLW and ILW at arising. The waste inventory at GDA estimates that all RPV ILW at arising will decay to LLW during the period awaiting GDF availability. However, if at the time of decommissioning any RPV segments are characterised and found to be ILW at disposal, the capability to manage them BAT and ALARP as ILW waste will be available to the future licensee. Characterisation and segregation will be applied as far as practicable, subject to future operator BAT and ALARP assessment, to the waste as it arises.

Characterisation at segmentation is anticipated to be easier and more effective than for the RIN. Segregation will potentially be more effective to identify:

- LLW for immediate management through the DWMF;
- ILW that will be LLW following decay awaiting GDF availability, and;
- ILW that will remain ILW until the GDF is available, and which may be packaged for disposal immediately.

The baseline RPV management strategy presented proposes buffer decay storage of ILW followed by characterisation, segregation and repackaging. The use of 3m^3 boxes and / or NFWC and overpacks followed by repackaging at the time of being sent to GDF provides an achievable solution however, it is recognised that it may not be optimal in terms of BAT and ALARP at the time of decommissioning. The

potential to use alternative ILW storage packages, or to package ILW immediately for disposal, remains open to the future operator subject to the application of BAT and ALARP.

The proposed management arrangements for RPV given in this report presents an achievable management solution that has the potential to be demonstrated BAT and ALARP. It does not foreclose other options or variations available to the future licensee that may be shown to be BAT and ALARP based upon their inputs and assessments at the time of decommissioning.

10.9.3.3 Decommissioning of the SFP and Rw/B

The SFP and its associated systems may be decontaminated and dismantled only when:

- An SF inspection and HLW (ILW following decay) repackaging facility has been constructed.
- There is no further requirement to temporarily store SF or highly activated items in the R/B; all SF and HLW to be stored have been packaged and transferred to their respective storage facilities.

The Rw/B and its associated systems may only be decontaminated and dismantled when:

- All retained water has been treated and discharged.
- The Decommissioning Waste Management facility is constructed and has the capability installed to manage the limited volumes of wet solid waste produced after all retained water has been treated and discharged.
- The Rw/B has processed its residual wet solid waste inventory following treatment of the retained water.

10.9.4 Phases 4 to 6: ILW Storage, Emptying and Disposal, HLW and SF Interim Storage, Repackaging and Disposal

In Phase 4 ILW packages in the ILWS, HLW casks in the HLW store and SF casks in the SFIS are stored in normal condition as described in PCSR Chapter 18 [Ref-7] and Chapter 32 [Ref-47]. Phase 4 begins when the Phase 3 power plant decommissioning is completed and includes the storage period until the GDF becomes available to receive ILW packages. If the planned date for GDF ILW receipt, 2100 [Ref-11], is achieved then there is potential for Phase 4 to overlap Phase 3.

In Phase 5 ILW packages will be exported from the ILWS for disposal at the GDF. HLW that has decayed during storage to ILW activity and heat generation levels will be repackaged into ILW disposal containers (e.g. $3m^3$ box) in the SF inspection and repackaging Hot Cell. ILW consignment to the GDF will be in accordance with the RWM requirements developed through the LoC procedure.

The Hot Cell for SF inspection and the repackaging of stored HLW will require a facility to manage its own solid waste such as the HLW storage canisters and overpacks, HEPA filters and wipes.

The Fuel Repackaging Facility design will have the capability to manage all dry solid waste associated with the repackaging of SF.

The SF canister activated metal will require characterisation, segregation and consignment to an appropriate disposal route: current solutions being metal recycling facility or volume reduction and consignment for direct disposal. The future site operator will make the BAT decision based on the waste characteristics and disposal options available at the time

The waste concrete overpacks and upper layer of the SFIS base slab may be activated and will require characterisation and segregation. The future site operator will make the BAT decision based on international operating experience, the waste characteristics and disposal options available at the time.

Current options include re-use as infill or disposal to VLLW landfill.

Final packaged SF will be consigned to the GDF in accordance with the RWM requirements developed through the LoC procedure.

10.9.5 Decontamination in Decommissioning

The aim of decontamination is to reduce the activity associated with waste items; to reduce dose to workers during decommissioning, prevent the potential spread of contamination (protection of the environment) and to reduce the volume of higher category waste (waste hierarchy). Decontamination can lead to a lowering of the radioactivity category of the waste, potentially reducing it to out of scope waste. However, the benefits of the decontamination need to be balanced against other factors such as secondary wastes generated and dose to workers during the decontamination process itself.

Decontamination is important in the decommissioning phase where waste volumes are high and decontamination can make significant improvements in waste classification. The predicted re-categorisation of decommissioning radioactive metal and concrete due to effective application of decontamination techniques is shown in Table 10.9.5-1.

Table 10.9.5-1: Recategorisation of Decommissioning Metal and Concrete after Decontamination

	Waste Category		Metal Waste (tonne)			Concrete Waste (tonne)			Total (tonne)
			Contamination	Irradiated	Subtotal	Contamination	Irradiated	Subtotal	
Decommissioning Waste before System Chemical Decontamination (A)	1	Intermediate Level Waste (ILW)	620	940	1,560	0	0	0	1,560
	2	Low Level Waste (LLW)	12,870	3,840	16,710	0	1,320	1,320	18,030
	3	Very Low Level Waste (VLLW)	1,220	1,110	2,330	90	2,880	2,970	5,300
	4	Exempt Waste (Exempt)	1,860	410	2,270	0	8,120	8,120	10,390
	5	Non-radioactive Waste (NR)	17,600			615,580			633,180
	6	Total	40,470			627,990			668,460
System Chemical Decontamination (A)-(B)		Diff. ILW	430	130	560				
		Diff. LLW	430	130	560				
		Diff. VLLW	0	0	0				
		Diff. Exempt	0	0	0				
Decommissioning Waste after System Chemical Decontamination (B)	1	Intermediate Level Waste (ILW)	190	810	1,000	0	0	0	1,000
	2	Low Level Waste (LLW)	13,300	3,970	17,270	0	1,320	1,320	18,590
	3	Very Low Level Waste (VLLW)	1,220	1,110	2,330	90	2,880	2,970	5,300
	4	Exempt Waste (Exempt)	1,860	410	2,270	0	8,120	8,120	10,390
	5	Non-radioactive Waste (NR)	17,600			615,580			633,180
	6	Total	40,470			627,990			668,460
Secondary Decontamination (B)-(C)		Diff. ILW	190	0	190				
		Diff. LLW	9,410	70	9,480				
		Diff. VLLW	8,380	20	8,400				
		Diff. Exempt	1,220	50	1,270				
Decommissioning Waste after Secondary Decontamination (C)	1	Intermediate Level Waste (ILW)	0	810	810	0	0	0	810
	2	Low Level Waste (LLW)	3,890	3,900	7,790	0	1,320	1,320	9,110
	3	Very Low Level Waste (VLLW)	9,600	1,130	10,730	90	2,880	2,970	13,700
	4	Exempt Waste (Exempt)	3,080	460	3,540	0	8,120	8,120	11,660
	5	Non-radioactive Waste (NR)	17,600			615,580			633,180
	6	Total	40,470			627,990			668,460

System chemical decontamination has previously been described in 10.9.2.5. Decontamination of items is discussed in the following sub-section.

10.9.5.1 Item Decontamination

Decontamination of operations waste is discussed in section 10.4.7. The PCSR Chapter 31 [Ref-11] and the Topic Report on Decommissioning Waste Management present the decommissioning decontamination strategy that is given in overview in this section. Decontamination operations anticipated to be performed during decommissioning can be crudely separated into two categories: in-situ decontamination of the inner surfaces of contaminated systems to reduce worker dose uptake on and around the systems during subsequent deplanting and ex-situ decontamination that may be applied to waste items at or after dismantling to aid waste management.

In-situ decontamination of steel liners and vessels

Despite design features to avoid and minimise the spread of contamination, steel liners and tanks within the UK ABWR power system and pools will require decontamination.

The target structures are tanks and pools that have been subjected to operational conditions that result in radioactive particulate deposition during operation. They have potential for a contamination concentration that raises the waste classification above that of the base material. Steel structures within the Reactor Building (R/B) potentially requiring decontamination include:

- SFP liner;
- Dryer Separator Pool (DSP) liner;
- Reactor well, and;
- Wet well Suppression Pool liner.

The application of UHP water jetting is the preferred decontamination option for these items and would generate a particulate bearing water secondary waste with similar characteristics to the plant retained water. The liquid waste is therefore anticipated to be processed through the LWMS, or replacement liquid waste management system, at decommissioning. Secondary waste management can be optimised BAT and ALARP.

Ex-situ decontamination

Ex-situ decontamination describes the decontamination techniques that may be applied to contaminated items following their deplanting / dismantling. The decontamination may be carried out in a designated, prepared area either local to the deplanting operations or remote such as in a purpose built Decommissioning Waste Management Facility (DWMF). Ex-situ decontamination employs a “tool-box” approach such that the optimal decontamination technique with consideration of BAT and ALARP may be applied. Examples of selected techniques are:

- Chemical decontamination (caustic soda or acid depending on target characteristics);
- Steam jetting;
- UHP water jetting;
- Abrasive blasting;
    - Wheel abrator;
    - Vacuum blast, and;
- Wiping.

Examples of items anticipated to be decontaminated locally include Turbine Building (T/B) large plant and equipment. Examples of items to be decontaminated in the DWMF include miscellaneous pipes, vessels, pumps and size reduced or dismantled equipment, for example from Rw/B deplanting operations.

Solid secondary wastes include used blast media and wipes which are identified in their respective tables in Appendix A as LLW non-combustible waste and LLW miscellaneous combustible waste.

11.Solid Waste Management Infrastructure

During the GDA process, designs have been considered for the waste treatment, processing and storage facilities required by the UK ABWR to accommodate the preferred solutions identified in section 10.8.

The figures and process descriptions given in this and subsequent sections do not represent final design decisions for the UK ABWR. Rather, they illustrate the facilities’ requirements and capabilities in order to demonstrate that the waste management operations as described in the PCSR Chapter 18, sections 18.6 *Wet-solid Waste Processing*, 18.10 *High Level Waste Processing*, 18.11 *Intermediate Level Processing* and 18.12 *Low Level Waste Processing* [Ref-7] are achievable.

HF considerations have and will be incorporated in the design of each facility of the UK ABWR under the HF Integration Plan. Where human factors are relied upon as part of the BAT case, these instances will be

fed into the HFI process outlined in PCSR Chapter 27: Human Factors [Ref-12]. All aspects of the waste management process during the entire site lifecycle will be carried out using Suitably Qualified and Experienced Persons (SQEP).

The main buildings and facilities required for the management and processing of solid radioactive wastes are:

- The Rw/B which accommodates all equipment associated with the collection and processing of solid and liquid radioactive waste generated by the plant, including;
    - A wet-solid LLW processing system to condition wet-solid LLW into a form compatible with disposal to the LLWR or other suitably permitted facility;
    - A wet-solid ILW processing system to condition wet-solid ILW into a passively safe form compatible with RWM requirements for ultimate disposal in the GDF.
- A solid-LLW facility to process waste into packages suitable for off-site consignment to appropriately licensed treatment and disposal facilities (incineration, recycling or direct disposal);
- A SF inspection and decay stored solid HLW treatment and repackaging facility. To inspect interim stored SF and to repackage decay stored HLW (calculated to be ILW at repackaging and disposal) into final waste packages compatible with RWM requirements for ultimate disposal in the GDF;
- A SF repackaging facility to repackage the SF into final disposal packages for dispatch to the GDF.

Brief descriptions of the solid radioactive waste processing systems are included in the PCSR Chapter 18: Radioactive Waste Management [Ref-7]. The design of the radwaste facilities will reference demonstrable BAT selection, best practice and compliance with UK regulations.

There are also facilities required for managing the storage of waste packages generated by the above facilities, specifically the:

- LLW temporary storage (Marshalling Area) of sufficient capacity to receive and temporarily store processed and packaged LLW, VLLW and out of scope waste pending dispatch from site to an appropriate disposal facility. The marshalling area may be associated with the LLW processing system depending on site characteristics.
- ILW interim store to store packaged ILW wastes prior to consignment to the GDF.
- Solid HLW Decay Storage Facility for storage of HLW activated metals prior to repackaging as ILW following decay and consignment to the GDF for disposal. The HLW Decay Storage Facility will be a separate building co-located with the SFIS.
- SFIS to safely store spent fuel until consignment to the GDF.

Waste treatment/packaging and storage requirements are described in the following sections for each stream of waste and SF to provide a base case.The waste management and storage facilities will be among the last facilities to be decommissioned on the generic site.

11.1 Dry-Solid Waste Processing System

The Dry-Solid Waste Processing System comprises the SWF and two sub-systems that are located in the Rw/B. The sub-systems that enable SLLW to be transported to the SWF in a safe and contained package are:

- the LLW MMA whose purpose is to receive solid waste packages, to monitor them for compliance with on-site transport limits and to transfer the waste packages out of the controlled areas to the SWF; and
- the LCW Filter Packaging Room.

The purpose of the SWF is to process and consign the SLLW for disposal ([Ref-7], section 18.12).

This section provides an overview of an example layout for a SWF. The figures and process descriptions given in this and subsequent sections do not represent a final design for the UK ABWR. They represent facility requirements and capabilities in order to demonstrate that the waste management operations as described in the PCSR Chapter 18 section 18.12 [Ref-7] are achievable.

The SWF processes the following wastes;

- Hollow fibre filter media in packages that may include shielded overpacked 500 litre drums (LCW filters) and Half Height ISO (HHISO) containers (CF),
- Miscellaneous combustible soft wastes such as paper, polythene, cloths etc. in 210 litre drums,
- Other miscellaneous non-combustible wastes including metals, cables, lagging, gas filters, concrete, glass, etc., comprising recyclable metal and non-recyclable material in 210 litre drums,
- Large metallic items in LLWR approved boxes,
- Activated Carbon from the LD system, dewatered and in 210 litre drums,
- HVAC HEPA filters in Berglof boxes [Ref-25] or 210 litre drums.

The facility is designed and sized to handle the annual volumes of these solid waste arisings as given in Appendix A: Waste Stream and Spent Fuel Descriptions.

The SWF is a self-contained building. Containment, ventilation and contamination control will prevent the spread of contamination to clean areas of the facility and outside of the building. The facility has fork lift truck access.

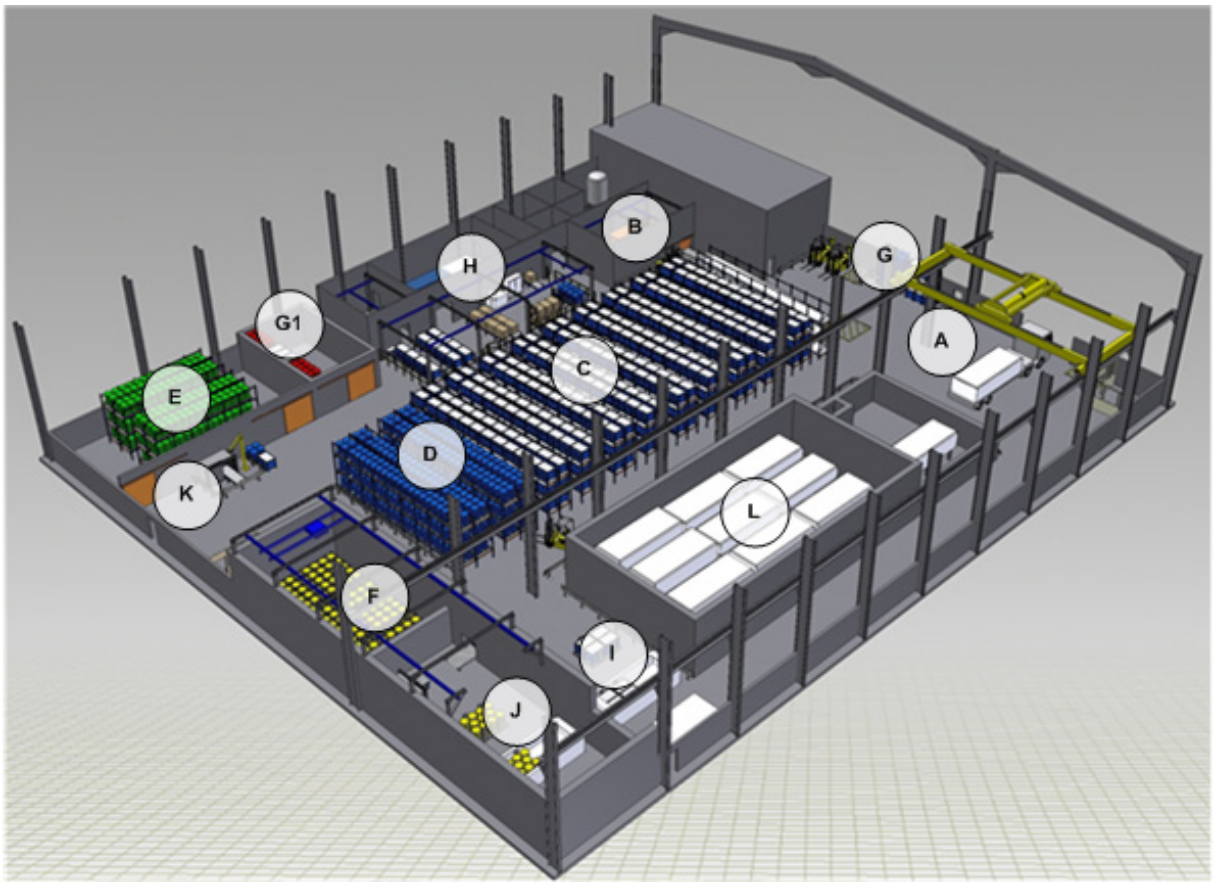
The waste is normally pre-sorted and segregated at the point of origin and transferred to the SWF via the LLW MMA. The purpose of the LLW MMA is to receive solid waste from the Reactor Building (R/B), the Turbine Building (T/B), the Service Building (S/B) and the Rw/B in waste packages and to monitor them for compliance with on-site transport limits, prior to transfer of the waste packages out of the controlled areas to the SWF. The majority of SLLW arising in the controlled areas exits through the LLW MMA, where it is consigned to the SWF. A summary of VLLW and LLW estimated waste quantities and package numbers is given in Appendix A, Table A2.3-1.

The SWF waste packages will be loaded into Half Height ISO (HHISO) containers for consignment to off-site disposal, incineration or recycling facilities as appropriate. The HHISO containers will be temporarily held in the ISO Marshalling Area prior to dispatch offsite.

The ISO Marshalling Area will also accommodate processed and packaged wet-solid LLW in the form of filled THISOs from the Wet-solid LLW processing system (WLLW) prior to their dispatch from site.

11.1.1 SWF Layout

The layout of an example SWF is illustrated in Figure 11.1.1-1. The figure does not represent a final design for the UK ABWR; it represents the facility requirements and capabilities in order to demonstrate that the waste management operations are achievable.



A	Receipt / dispatch bay	G, G1	Quarantine Area
B	Glovebox inspection area	H	Compaction area
C	Berglof box storage racking	I	HHISO loading area
D	210 litre drum storage racking	J	Shielded HHISO loading area
E	Decay store	K	Assay point
F	Shielded drum store	L	ISO marshalling area

Figure 11.1.1-1: Layout Example for SWF

11.1.2 SWF Processes

The main processes within the SWF are:

- The receipt and categorisation of waste.

- The routine inspection of waste and the inspection of non-compliant waste packages.
- The storage and treatment of HEPA filters.
- The decay storage and package management of Hollow Fibre Filters.
- The storage of BAC/GAC.
- The storage and treatment of Miscellaneous Combustible waste.
- The storage and dispatch of Metals for Recycling.
- The storage and treatment of Miscellaneous Non-Combustible waste.
- The provision of an ISO Marshalling Area.

11.1.2.1 Waste Receipt and Categorisation

Solid LLW will be segregated at source or as close to source as practicable, packaged appropriately to its type and clearly identified in accordance with the waste tracking system (see 11.8) prior to transfer to the SWF. Typically waste consigned to the SWF will pass via the Rw/B MMA where it will be monitored and checked for SWF acceptance prior to transfer. Any waste decontamination operations will be carried out at source prior to packaging and dispatch to the SWF.

It is assumed that all waste being delivered to this facility will be double wrapped and contained in a suitable package, for example a 210 litre drum, a Berglof box or a WB1 Waste Box. The waste is off-loaded from the onsite transfer vehicle in the receipt bay (A) and inspected to ensure it is as expected, not damaged and is accompanied by adequate documentation. Non-compliant waste packages will be returned to the donor facility. In the unlikely event that the donor facility cannot receive the returned package, the waste package will be consigned to the appropriate Quarantine Area (G) while a suitable and prompt course of action is determined. If the waste is acceptable it is subject to a Health Physics check. If a drum of waste requires inspection (due to the weight being at an unexpected level for the waste type, or if a routine check is required), the drum is sent to the Glovebox Inspection Area (B). If not, the waste is fed into one of the remaining waste streams. Inspection of non-drum packages such as Berglof boxes or WB1 waste boxes will not be undertaken using the glovebox but would be opened under controlled conditions within the Quarantine Store (G1) if required.

11.1.2.2 Glovebox Inspection

The SWF will have the capacity to inspect and repackage drums ([Ref-7] section 18.12). This section presents an example of such a capacity may be realised. It should be noted that the purpose of the MMA in the waste transfer route from arising to SWF is to ensure that the requirement for inspection and repackaging within the SWF is minimised. The Glovebox Inspection Area (B) is designed to allow inspection of 210 litre drums from either the shielded (F) or non-shielded (D) storage areas. Inspection of drums is not part of the standard process and will only be undertaken if the package has been damaged in transit or if there is some issue with the documentation that can only be resolved by visual inspection. Regulator inspection to confirm drum content of drums in storage may also be required. The process for inspection of drum contents for any reason is as follows.

Inspection of drums stored in the unshielded storage area

The Glovebox Inspection Area (B) allows an unshielded 210 litre drum to be opened, the contents placed onto a sorting table and then either replaced back into the original drum (if the contents are acceptable) or segregated into one of the following three waste types:

1) Waste for incineration,

2) Waste for burial,

3) Metals for re-cycling.

If the contents of the drum are not acceptable they are re-sorted and placed into one of the three waste drums as listed above, before being managed through the appropriate route within the facility.

If the original drum contents are found to be acceptable, the original drum will be re-filled and returned to the relevant waste segregated storage area.

Should a drum stored in the Shielded Drum Store (F) require inspection, this can be brought to the Glovebox Inspection Area (B) using a forklift truck and a shielded pot to provide an appropriate level of shielding. If the contents are not as expected then the drum is placed in the Shielded Quarantine Area (G1) awaiting a remediation strategy. If sorting of a drum of this type was deemed necessary, abnormal working arrangements would be required and would be governed by Health Physics support to ensure the operation was as efficient as possible and minimised operator dose uptake.

11.1.2.3 HEPA Filter Storage and Treatment

The HEPA filters are imported into the facility in an appropriate package such as a 210 litre drum. The filters will be segregated at source into combustible LLW waste or non-combustible LLW based upon their type, history and characterization. Due to the large volume and low mass of these filters they will be compacted to reduce their volume prior to being sent for incineration or disposal. The process for managing the HEPA filters through the SWF is illustrated in Figure 11.1.2-1.

11.1.2.4 Hollow Fibre Filter Storage and Treatment

Hollow fibre filters will be transferred to the SWF in appropriate packages and/or containers which will depend upon the final filter design, radioactivity and handling requirements. Depending on the radioactivity of the contamination fixed to the filters at removal from the system, treatment of the filters prior to receipt at the SWF may include encapsulation in cement.

LCW filters will be packaged into 500 litre drums and placed in a shielded overpack in the LCW filter packaging room prior to being transferred to the SWF via the MMA. The overpacked drum will be decay stored at the SWF before being monitored, assayed and consigned for disposal at the LLWR.

CF filters may be packaged into drums in the T/B and transferred to the SWF via the MMA. Alternatively, the option is available to package directly into a THISO or HHISO in the T/B and either consign for disposal directly to the LLWR or transfer to the SWF ISO marshalling area.

11.1.2.5 BAC Storage

BAC and GAC arising from the Laundry Drains processing system will be characterised and segregated at source. Waste that is, or after a demonstrably BAT period of decay storage will be, within the acceptance criteria for incineration, will be transferred to the SWF in 210 litre drums. Shielded decay storage to allow the radioactivity to decay to within incineration facility acceptable criteria is provided.

Following decay storage, the BAC/GAC will be removed from the Shielded Decay Store and assayed to confirm the radioactivity has decayed to an acceptable level for consignment to a permitted incineration facility.

The process for managing the BAC through the SWF is illustrated in Figure 11.1.2-2. The process assumes compliant packages, however, should this not be the case and investigation and inspection of the waste is required, the processes described in sections 11.1.2.1 and 11.1.2.2 will be applied.

BAC/GAC that characterisation shows will be outside the acceptance criteria for incineration at the end of the site operator's defined BAT decay period may be considered for treatment and disposal as wet solid

LLW in a similar way to the potentially more radioactive GAC as described in section 11.2.

11.1.2.6 Miscellaneous Combustible Storage and Treatment

Miscellaneous combustible waste will be segregated at source before being transferred to the SWF in 210 litre drums.

Due to the typically large volume and low mass of this waste stream, the waste will be compacted to reduce volume prior to being sent for incineration.

The process for managing the miscellaneous combustible waste through the SWF is illustrated in Figure 11.1.2-3. The process assumes compliant packages, however, should this not be the case and investigation and inspection of the waste is required, the processes described in sections 11.1.2.1 and 11.1.2.2 will be applied.

11.1.2.7 Metals for Recycling and Treatment

Metal wastes suitable for recycling will be segregated at source and transferred to the SWF in 210 litre drums as standard. Larger items may be imported using WB1 waste boxes.

The process for managing the recyclable metal wastes through the SWF is illustrated in Figure 11.1.2-4. The process assumes compliant packages, however, should this not be the case and investigation and inspection of the waste is required, the processes described in sections 11.1.2.1 and 11.1.2.2 will be applied.

11.1.2.8 Miscellaneous Non-Combustible Storage and Treatment

Non-combustible waste will be segregated at source in terms of waste type and radioactivity such that VLLW is identified and managed separately to LLW. The segregated VLLW and LLW will be transferred to the SWF in 210 litre drums. The SWF provides for segregated storage of VLLW and LLW.

The process for managing miscellaneous non-combustible wastes through the SWF is illustrated in Figure 11.1.2-5. The process assumes compliant packages, however, should this not be the case and investigation and inspection of the waste is required, the processes described in sections 11.1.2.1 and 11.1.2.2 will be applied.

11.1.2.9 ISO Marshalling Area

The ISO marshalling area (L) is designed to accommodate the following operations:

- Receipt and inspection of clean HHISO containers to ensure that they are as expected and, where appropriate, are pre-loaded with the appropriate stillages;
- Storage of clean HHISO containers awaiting use within the SWF;
- Transfer of clean HHISO containers to the appropriate loading area within the SWF;
- Receipt and inspection of new compaction boxes and clean Berglof boxes;
- Receipt of HHISOs filled within the SWF;
- Receipt of full THISO transferred from the WLLW;
- Interim storage of the HHISO and THISO containers pending consignment to appropriate off-site disposal facilities.

Depending on the ISO type and the final destination (for disposal, recycling or incineration) the ISO is placed in a specific storage location within the ISO Marshalling Area.

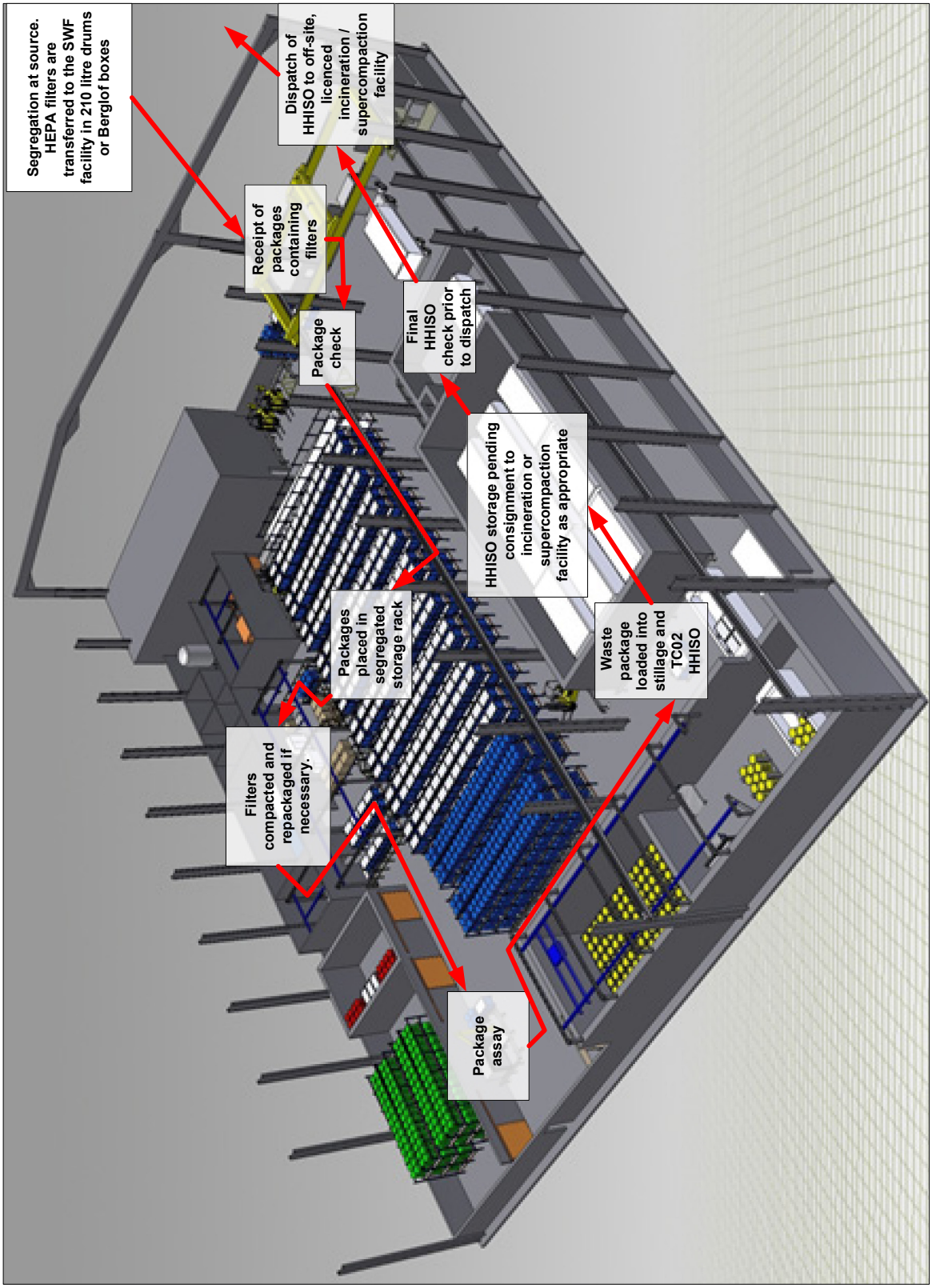


Figure 11.1.2-1: Example HEPA Filter Treatment Process

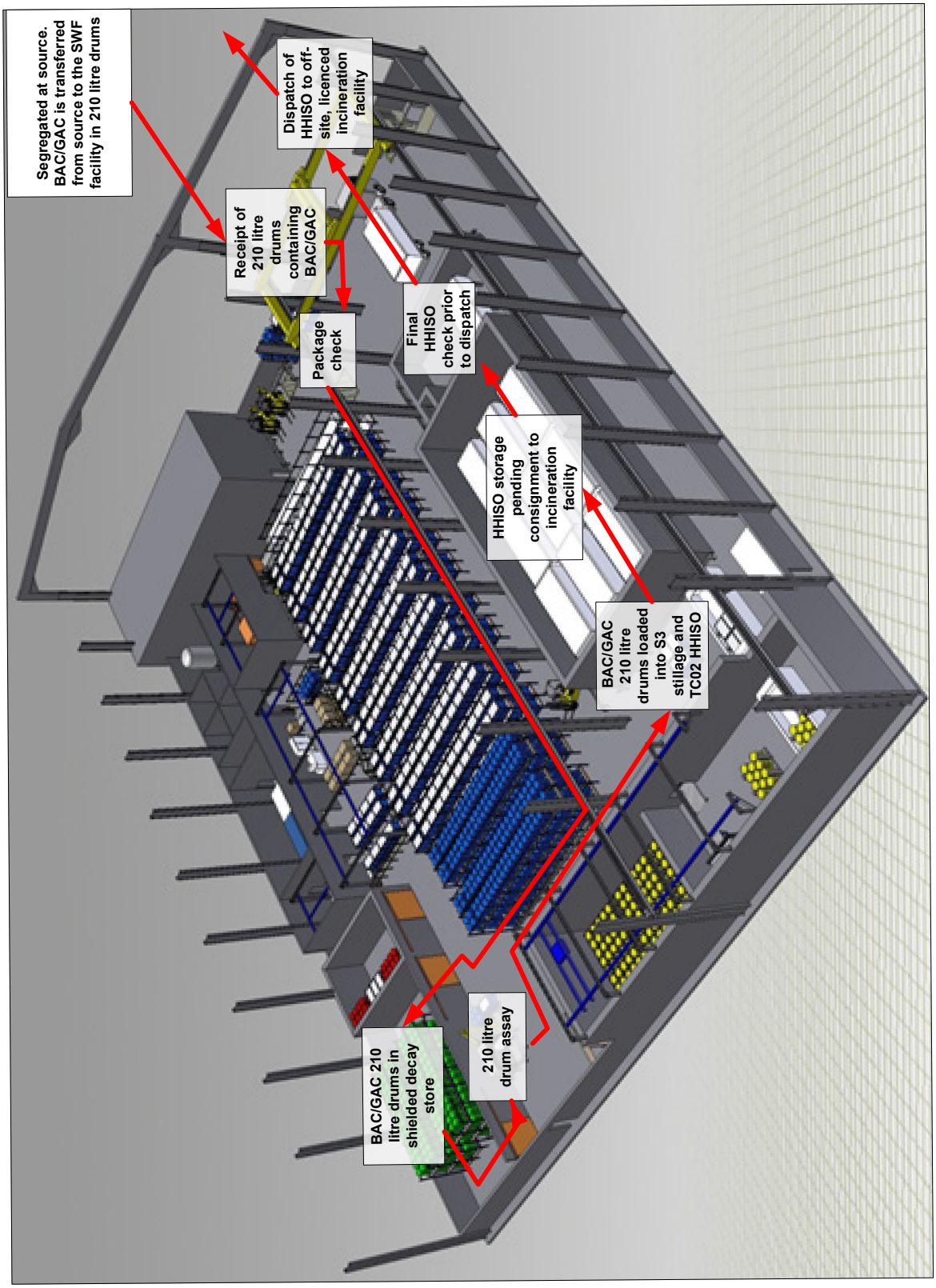


Figure 11.1.2-2: Example BAC /GAC Storage and Treatment Process

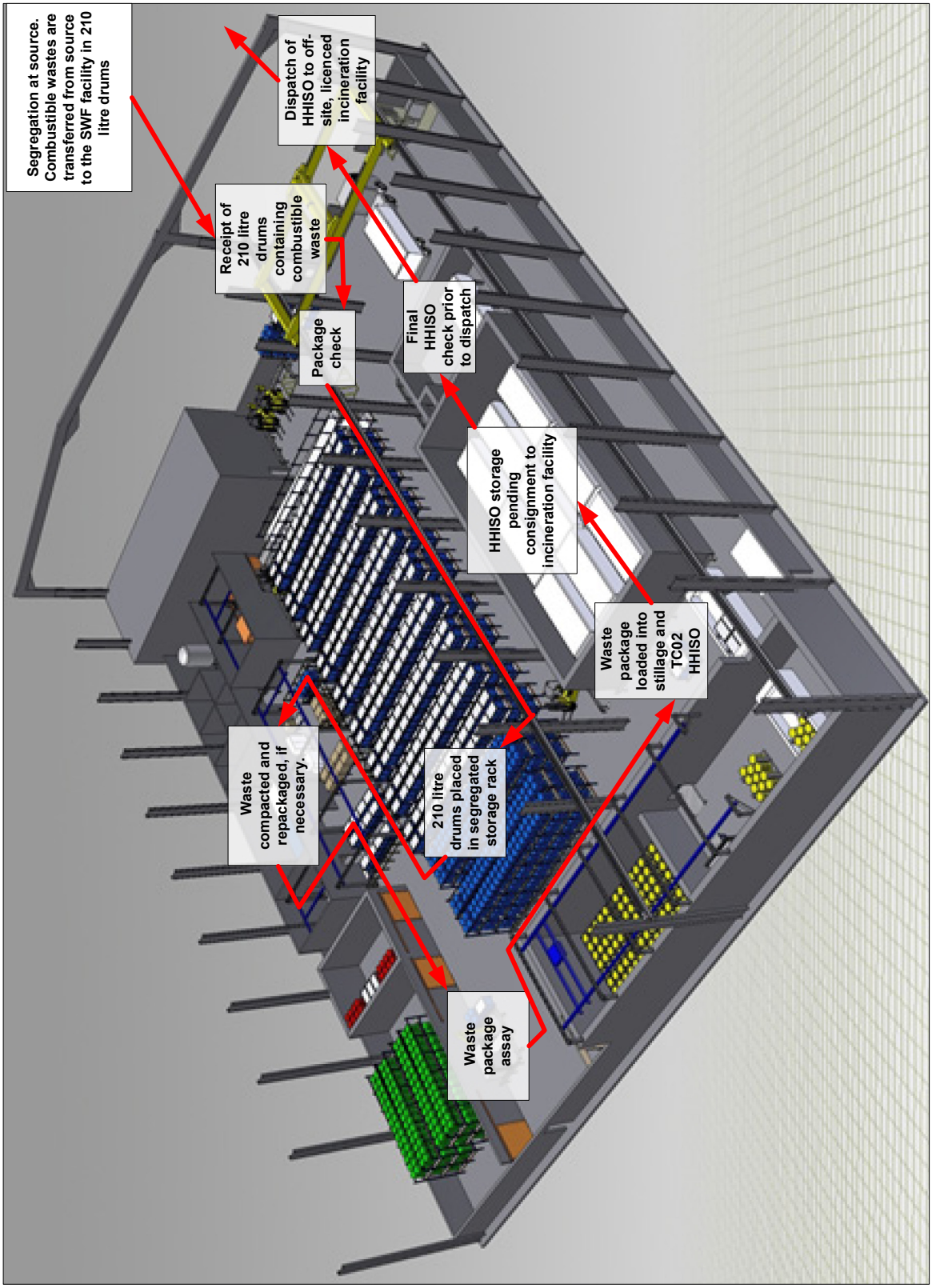


Figure 11.1.2-3: Example Miscellaneous Combustible Storage and Treatment Process

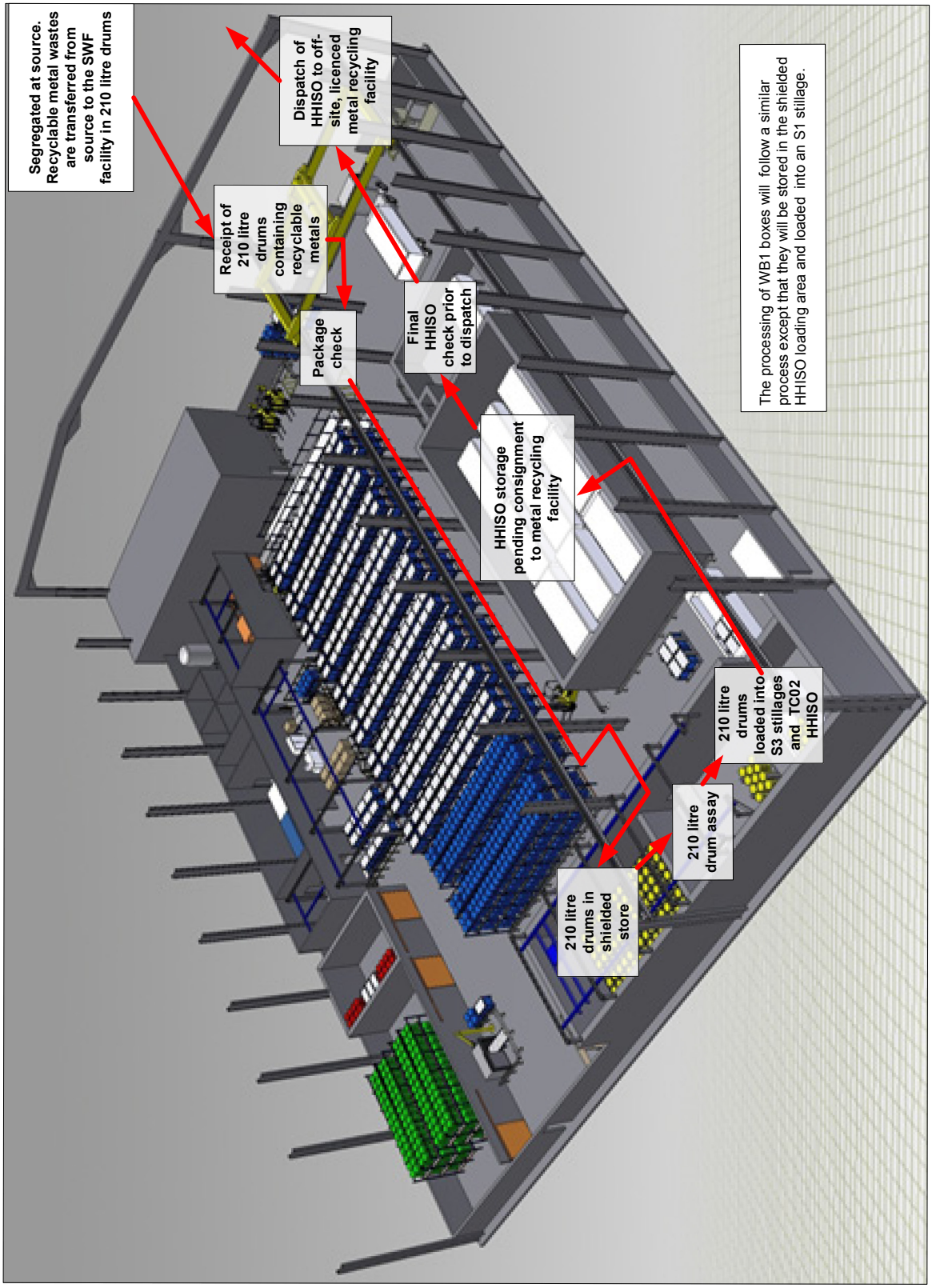


Figure 11.1.2-4: Example Metal for Recycling and Treatment Process

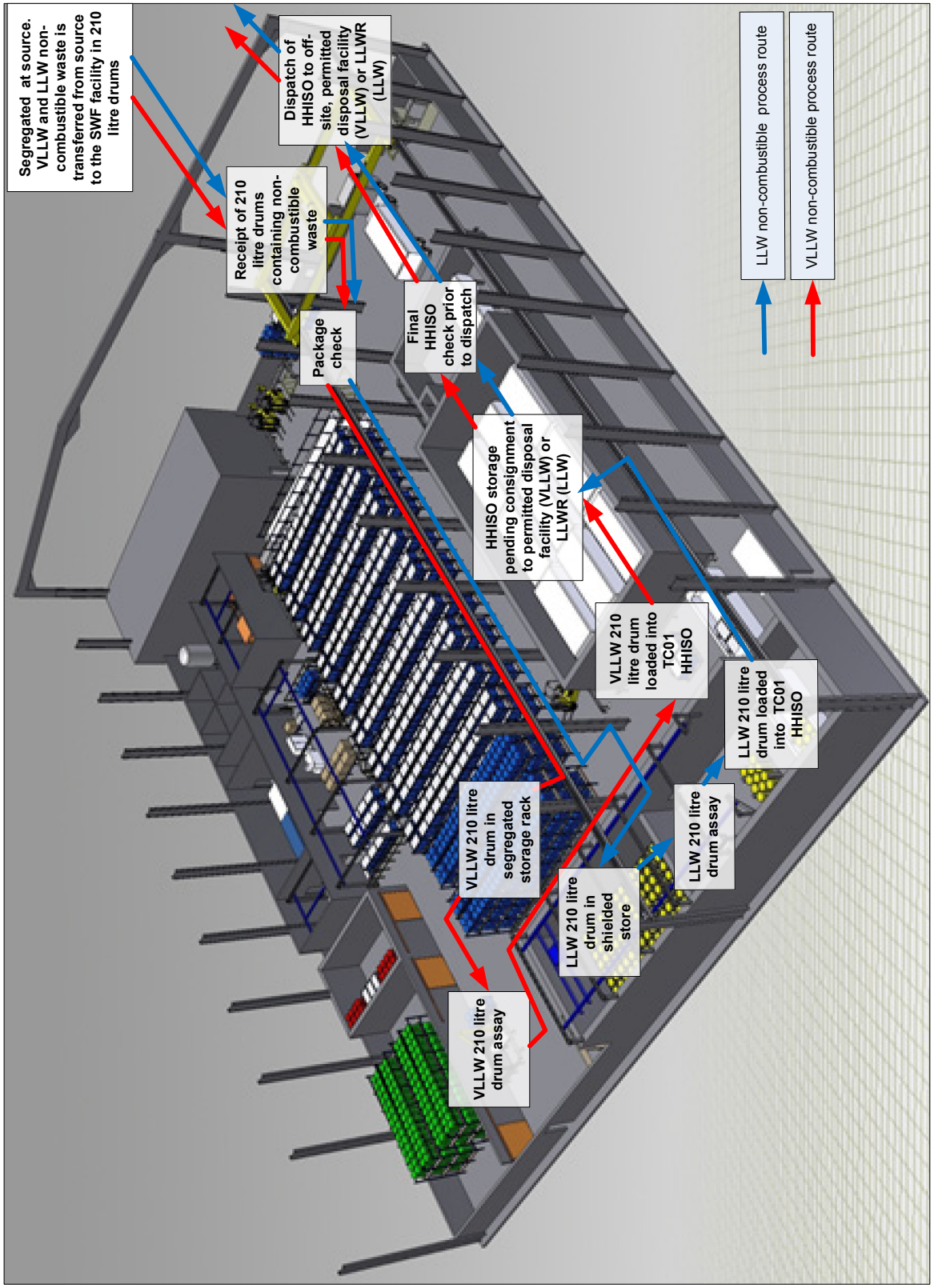


Figure 11.1.2-5: Example Miscellaneous Non-combustible Storage and Treatment Process

11.1.3 Secondary Wastes

Solid secondary wastes will be generated in the SWF as a result of normal operations and will be managed as follows:

- Emptied 210 litre drums and Berglof boxes will be returned to a central on-site store prior to re-use.
- Drum pallets will also be returned to a central store for re-use.
- Radioactive waste, including filters from the Mobile Filtration Unit and the fixed ventilation system, PPE and components from operational plant following maintenance activities will be managed within the SWF itself.

11.1.4 Gaseous and Liquid Discharges

Radioactive gaseous and liquid effluents will be minimised.

To maintain protection of the worker, the public and the environment, mobile filtration units and a dedicated ventilation system will manage potentially contaminated air flows in areas where waste packages may be opened for inspection, compaction or repackaging. The ventilation units and system will include HEPA filtration. Any “active” ventilation system discharge to atmosphere will be via a dedicated sampling and monitoring system before discharge from a dedicated stack.

Non active liquid effluent (hand washing and toilets) from within the main office/admin block will be fed directly to the site main drainage system.

Any potentially radioactive liquid effluent will be low volume, low radioactivity from personnel hand washing and emergency shower facilities. The water will be collected, monitored and transferred by suitable means to the appropriate radioactive liquid treatment system for the site.

11.1.5 Radiological Monitoring and Assay

Hand held radiation and contamination probes as well as installed waste package assay systems will be utilised within the SWF. The Radioactive Solid Wastes Monitoring Requirements document [Ref-10]discusses and presents the SWF monitoring requirements in more detail.

Sections 11.8 and 11.9 discuss the requirement for a waste tracking and management system and a Quality Assurance (QA) system.

11.1.6 Design Life and Decommissioning

The SWF has a design life of 90 years based on reactor operations for a period of 60 years followed by support to site decommissioning for a further 30 years. The wastes to be generated at decommissioning are assumed to be similar to the operational wastes the facility will deal with on a day to day basis during reactor operations.

11.2 Wet-Solid Low Level Waste Processing System (WLLW)

This section provides an overview of an example WLLW. The figures and process descriptions given in this and subsequent sections do not represent a final design for the UK ABWR. They represent facility requirements and capabilities in order to demonstrate that the waste management operations as described in the PCSR Chapter 18 section 18.6 [Ref-7] are achievable.

The WLLW processes operational wet-solid LLW in the UK ABWR Rw/B, including:

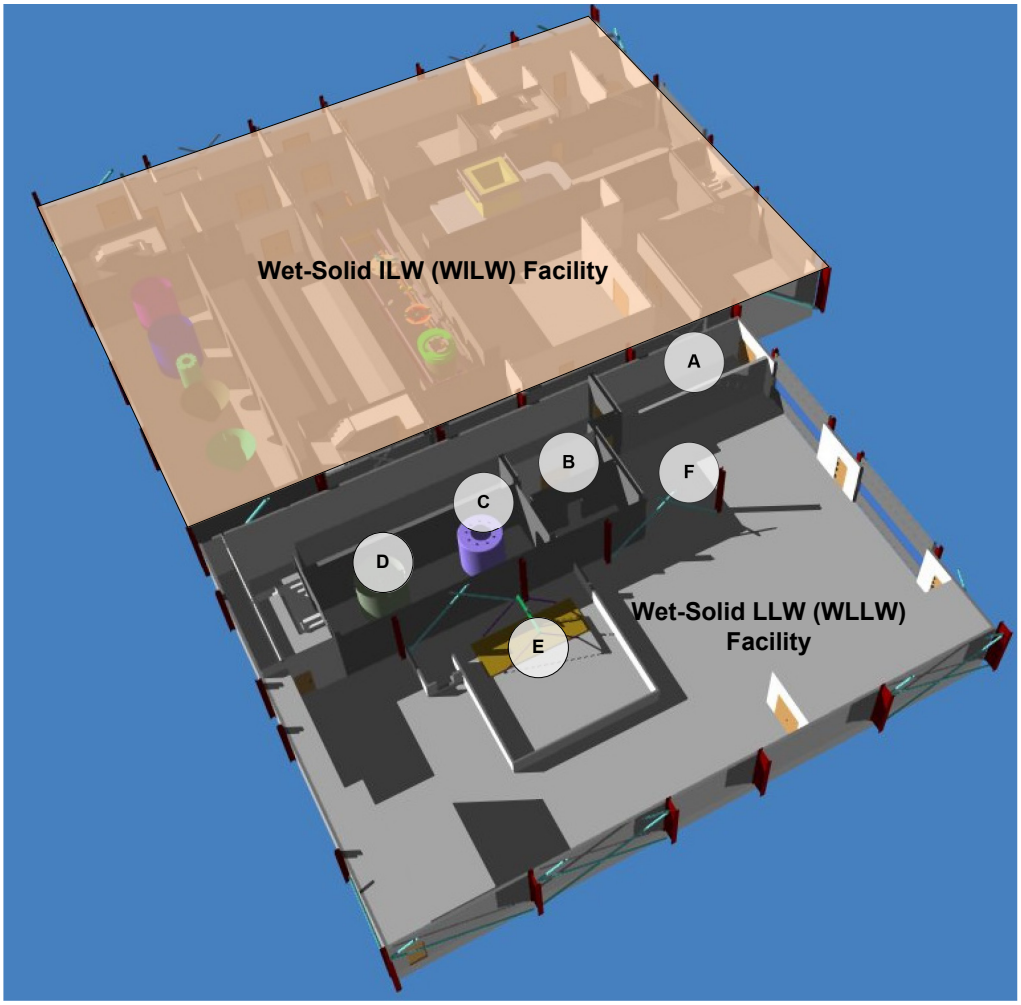
- Spent ion exchange resins from:
  - The Condensate Demineraliser (CD) (estimated quantity 9.6m^3 per year)
  - The LCW demineraliser (estimated quantity 1.7m^3 per year)
  - The HCW demineraliser (estimated quantity 0.3m^3 per year)
- Concentrated sludge from the HCW evaporator Concentrated Waste Storage Tanks (estimated quantity 1m^3 per year)
- GAC from the Activated Carbon Adsorption Tower; a part of the Laundry Drains (LD) sub-system (estimated quantity 0.6m^3 per year) that is unsuitable for incineration.

The treatment process immobilises the waste in cement following a waste / cement formulation proven to produce a compliant, disposable LLW waste form. The WLLW can contain solidification equipment to process LLW waste packages appropriate to the volume and specific radioactivity of the waste. For example, relatively small volumes of waste or higher radioactivity waste, whose batch volumes for processing are constrained by worker dose controls, may be processed using a drum based system. Larger volumes of relatively lower specific radioactivity waste may utilise an in line mixing system and a THISO as the waste package. Both systems are designed around a waste process that:

- Receives and blends the waste according to an approved formulation;
- Mixes the waste blend with cement powder in the ratio specified by the formulation either in, or during filling of, the final waste package;
- Allows the waste / cement mixture to cure to produce an acceptable and disposable monolithic waste form.
- Dispatches filled and cured waste packages to the SWF for interim storage pending off-site consignment to a suitable disposal facility such as the LLWR.
- Dispatches filled and cured waste packages to a shielded store for decay storage (where required) pending off-site consignment to a suitable disposal facility such as the LLWR.

11.2.1 WLLW Layout

The WLLW is an integral part of the Rw/B. The layout of an example WLLW is illustrated in Figure 11.2.1-1. The figure does not present a design for the UK ABWR; it represents the facility requirements and capabilities in order to demonstrate that the waste management operations are achievable.



A	GAC receipt area	D	Hydrocyclone break tank
B	Drum solidification area	E	THISO
C	1st floor: Resin hydrocyclone Ground floor: LLW Process tank	F	Cement powder preparation area

Figure 11.2.1-1: Example WLLW Layout

11.2.2 WLLW Processes

The WLLW are illustrated in Figure 11.2.2-1. Example cement solidification systems that have been successfully deployed in Japan and the UK are shown in Figures 11.2.2-2 to 11.2.2-4.

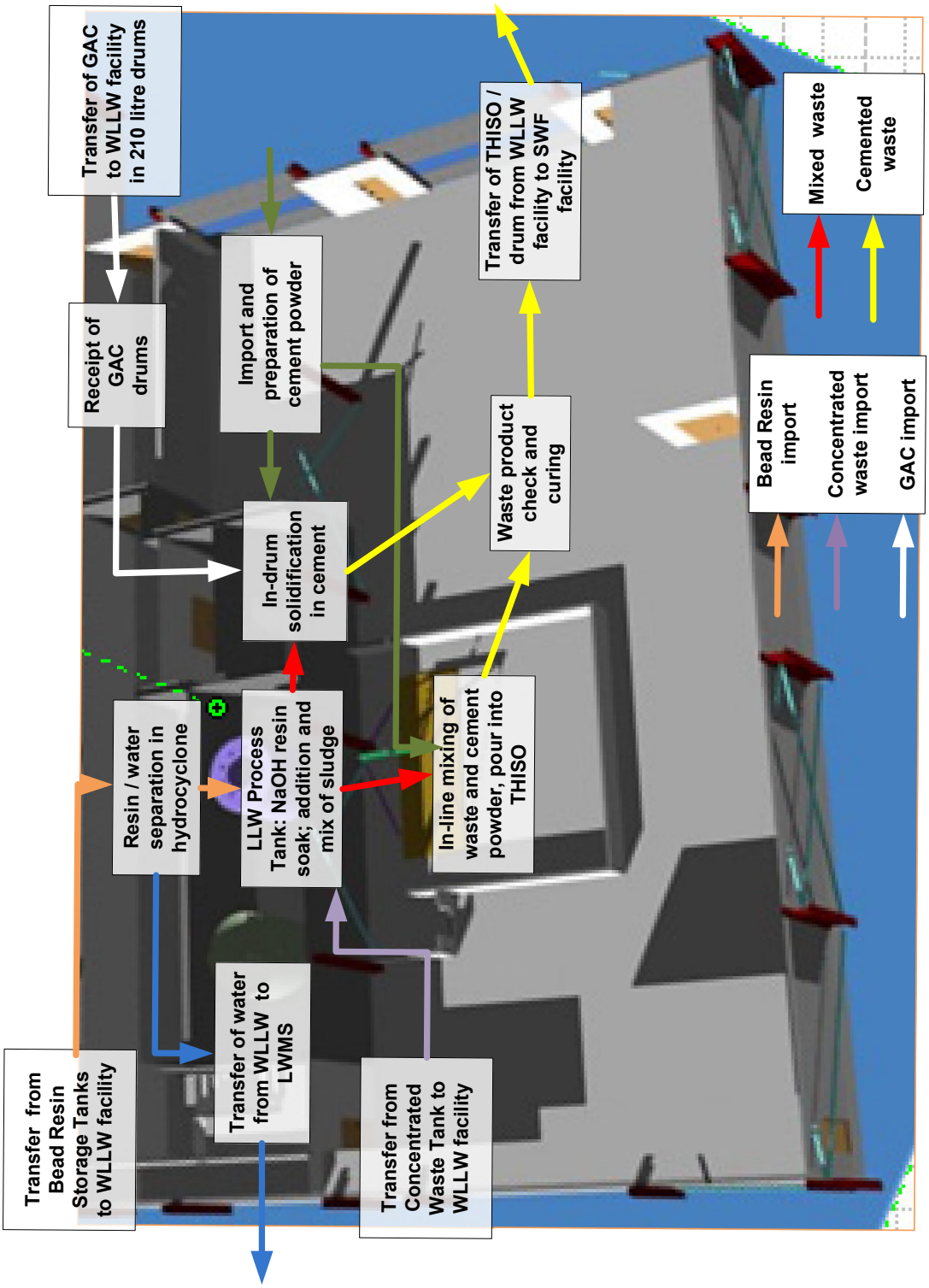


Figure 11.2.2-1: Example WLLW Processes

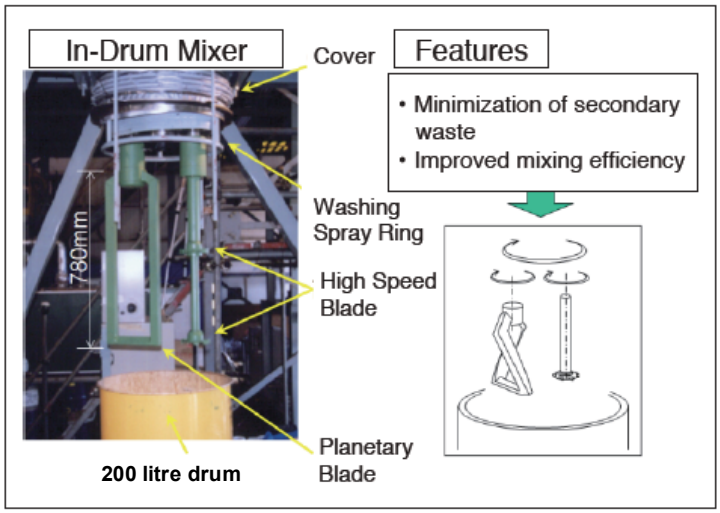


Figure 11.2.2-2: An Example In-drum Mixer as Deployed in Japan

Figure 11.2.2-3: A Mobile Shielded In-drum Solidification Plant for Higher Activity LLW as Deployed in the UK

Figure 11.2.2-4: In-line Mixing and Pouring into a THISO as Deployed in the UK

11.2.3 Secondary Wastes

As far as possible, secondary waste will be minimised, or be absorbed into the process itself. The secondary wastes produced in the WLLW will be:

- Flushing water streams for tanks, pumps and transfer lines. As far as possible the volumes of water used will be absorbed into the process streams so, e.g. water used to flush the LLW Process Tank discharge line will be directed to the waste package.
- The in-line mixer used to deliver LLW and wet grout to the THISO will be disposed of directly into the THISO.
- Commercial suppliers provide modular, mobile in-drum encapsulation systems that can be installed for waste processing campaigns. The plants are re-used at other sites and remain the property of the service supplier.
- Installed or temporary drum cementation systems are designed to minimise secondary wastes with effective seals and lost paddle systems to prevent contamination spread outside the process drum.
- All equipment in the wet LLW processing area will be selected on the basis of minimum maintenance; inevitably some waste may be created (e.g. pump seals valves/gaskets etc.,); these are mainly dry-solid LLW items which will be transferred to the SWF.

11.2.4 Gaseous and Liquid Discharges

Gaseous discharges will be managed by the Rw/B HVAC system.

During a campaign non-radioactive grout wash water will be stored and reused. Any non-radioactive grout wash water still remaining at the end of a campaign will be treated to remove cement residues and discharged to an appropriate site drain.

11.2.5 Process and Waste Product Monitoring

Samples of any active solid waste materials will be analysed on line where practicable to minimise the need to draw, package or transport samples to an external analytical facility. Sampling points with appropriate provision for process analyser instruments will be fitted as necessary and will be provided with flushing water where appropriate.

Process monitoring and control will ensure a compliant final waste package and may include:

(i) Solids content determination of the material in the LLW Process Tank by a simple density measurement prior to its discharge to the THISO or drum.

(ii) Measurement of the radioactivity of the material in the LLW Process Tank using a beta-gamma monitor.

(iii) Confirmation dose rate monitoring of the final cured waste package, the application of an appropriate radionuclide fingerprint and comparison with the LLWR WAC.

The Radioactive Solid Wastes Monitoring Requirements document [Ref-10] discusses and presents the WLLW monitoring requirements in more detail.

Sections 11.8 and 11.9 discuss the requirement for a waste tracking and management system and a QA system.

11.2.6 Design Life and Decommissioning

The WLLW will be decommissioned at the same time as the rest of the Rw/B at the end of Decommissioning Phase 3 (10.9.3.3). At decommissioning, residual wet wastes will be flushed from the system and processed in the WLLW. Solid decommissioning wastes will be treated and packaged in the Decommissioning Waste Management facility.

11.3 Wet-Solid Intermediate Level Waste Processing System (WILW)

This section provides an overview of an example WILW. The figures and process descriptions given in this and subsequent sections do not represent a final design for the UK ABWR. They represent facility requirements and capabilities in order to demonstrate that the waste management operations as described in the PCSR Chapter 18 section 18.6 [Ref-7] are achievable.

The WILW processes operational wet-solid ILW within the Rw/B, including:

- Powder, organic ion exchange resins from:
  - The Reactor Clean-up Water (CUW) filter demineraliser (estimated quantity 3.1m^3 per year)
  - The FPC filter demineraliser (estimated quantity 1.3m^3 per year)
- Filter cruds from:
  - The Condensate Filter (estimated quantity 1.2m^3 per year)
  - The LCW filter (estimated quantity 0.3m^3 per year)

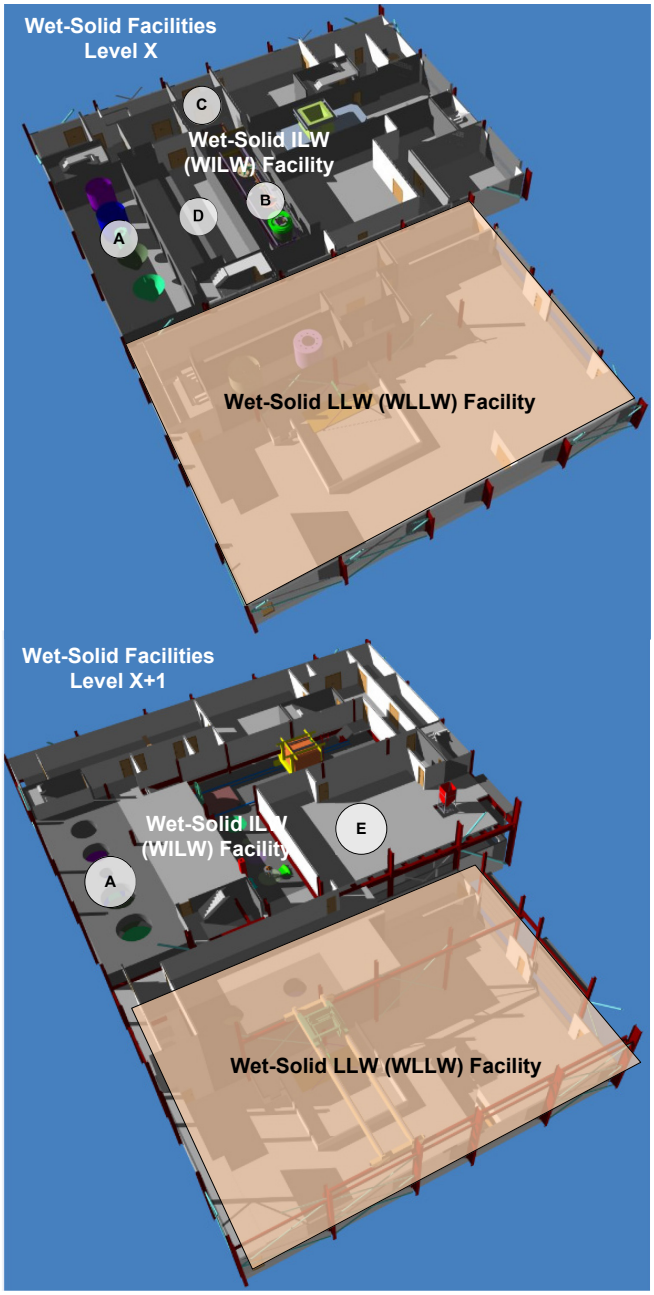
The treatment process immobilises the waste in cement following a waste / cement formulation proven to produce a GDF compliant waste product. The WILW building is designed around a waste process that:

- Receives and holds batches of the waste identified above prior to processing;
- Pre-treats the organic resin with a caustic soda (NaOH) soak;
- Blends the waste ingredients in controlled and measured quantities according to the approved and accepted waste formulation;

- Loads a $3m^3$ drum with blended waste according to the waste formulation;
- In-drum mixes the blended waste with a controlled, measured cement addition;
- Allows the waste / cement mixture to cure in the $3m^3$ drum to produce an acceptable and disposable monolithic waste form.
- Check and dispatch filled and cured $3m^3$ drums to ILWS for interim storage pending off-site consignment to the GDF.

11.3.1 WILW Layout

The WILW is an integral part of the Rw/B. The layout of an example WILW is illustrated in Figure 11.3.1-1. The figure does not present a design for the UK ABWR; it represents the facility requirements and capabilities in order to demonstrate that the waste management operations are achievable.



A	WILW Processing Cell: • ILW process tank
B	Processing plant and equipment area (pumps & pipework)
C	Modular ILW Solidification Plant (MILWSP)
D	Package check and export area
E	Grout preparation area

Figure 11.3.1-1: Example WILW Layout

11.3.2 WILW Processes

The WILW processes are illustrated in Figure 11.3.2-1. Movement of waste packages will be within Secondary Containment Vessels (SCV). The SCVs will ensure the cleanliness of packages during handling, process and transfer operations. Packages identified as non-conformant may remain within the SCV throughout treatment and interim storage as necessary to maintain waste containment and external cleanliness.

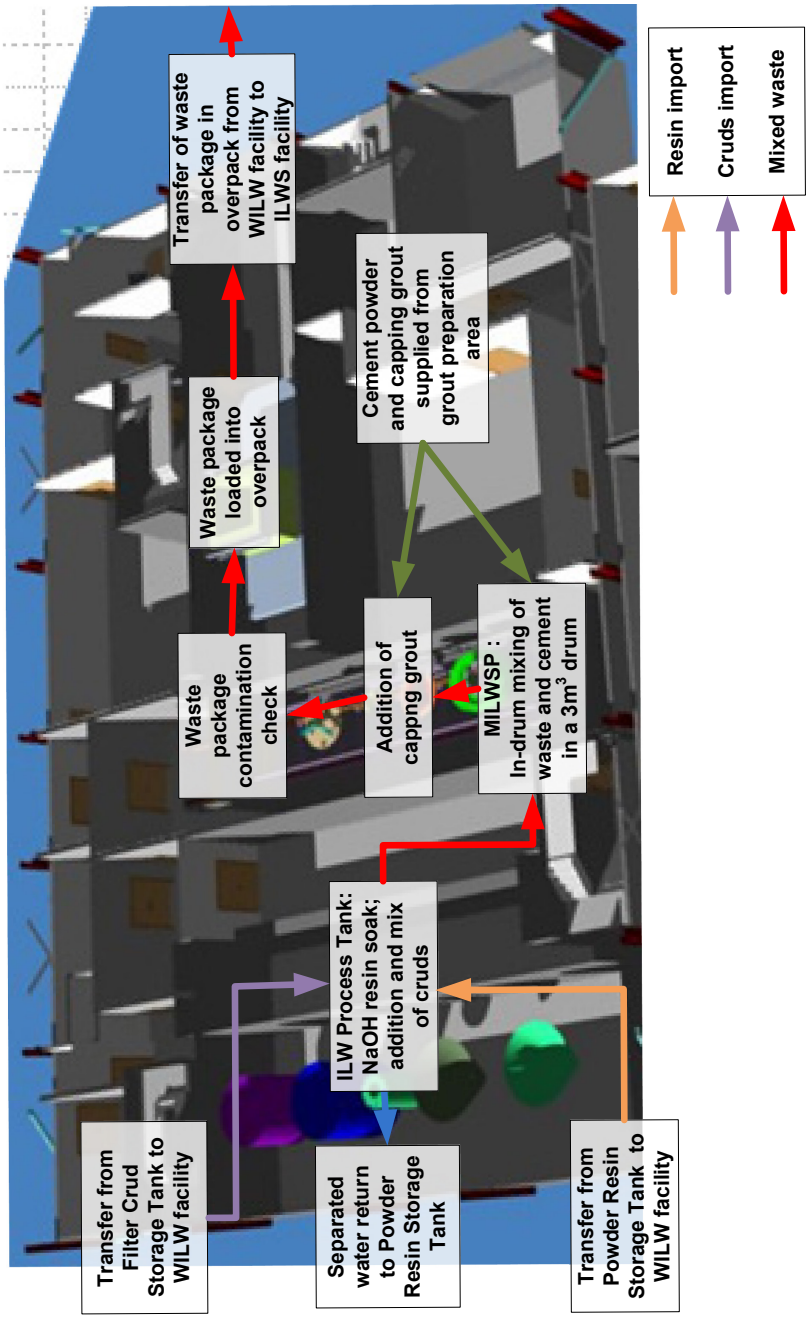


Figure 11.3.2-1: Example WILW Processes

11.3.3 Secondary Wastes

As far as possible, secondary waste will be minimised (or be absorbed into the process itself). The

secondary wastes produced in the wet-solid ILW will be:

- Flushing water streams for tanks, pumps and transfer lines. As far as possible the volumes of water used will be absorbed into the process streams so, e.g. water used to flush the ILW Waste Conditioning Tank will be directed to the $3m^3$ drum.
- Waste items arising from operations and contamination monitoring; for example swabs from $3m^3$ drums and secondary containment vessels and suspected LLW items such as the end of the capping grout delivery hose will be managed as dry-solid LLW.

All equipment in the wet ILW Processing Cell (A) will be selected on the basis of minimum maintenance. Inevitably some active waste may be created (e.g. pump seals, remote cameras, valves, HEPA filters etc.,); these are mainly solid waste items which will be monitored, appropriately segregated and transferred to the SWF.

11.3.4 Gaseous and Liquid Discharges

Gaseous discharges will be managed by the Rw/B HVAC system.

Radioactively contaminated effluent from the Powder Resin Settling Tanks is collected and re-used in the Rw/B.

11.3.5 Process and Waste Product Monitoring

Process monitoring and control will ensure a compliant final waste package and may include:

- Level sensors in vessels.
- The solids content of the material in the ILW process tank is determined by a simple density measurement prior to its discharge to the $3m^3$ drum.
- The radioactivity of the material in the sentencing vessel is determined using a gamma monitor.
- MILWSP will be fitted with a system for measuring the mass of the contents of the $3m^3$ drums, detectors to measure the dose from the completed $3m^3$ drum before export from MILWSP and a means of sampling and checking for external contamination of the final waste package ($3m^3$ drum and / or SCV).

The Radioactive Solid Wastes Monitoring Requirements document [Ref-10] discusses and presents the WILW monitoring requirements in more detail.

Sections 11.8 and 11.9 discuss the requirement for a waste tracking and management system and a QA system.

11.3.6 Design Life and Decommissioning

The WILW will be decommissioned at the same time as the rest of the Rw/B at the end of Decommissioning Phase 3 (10.9.3.3). At decommissioning, residual wet wastes will be flushed from the system and processed in the WILW. Solid decommissioning wastes will be treated and packaged in the Decommissioning Waste Management facility.

11.4 Solid HLW and ILW (SILW) Facilities

Facilities will be required during operation and decommissioning to manage control rods and core activated components that are HLW at arising, between their SFP buffer storage period and dispatch off-site to the GDF. The management options for operational solid HLW (ILW after decay) have been assessed during GDA and are presented in the Management of Dry Solid ILW optioneering report [Ref-45]. The

optioneering report aims to support the overall demonstration of BAT for the selection of a base case solid ILW management solution; providing a point of reference for stakeholders and future site operators with a view to develop a complete suite of documentation in line with safety case delivery and EP-RSR permit application.

The SILW facility (also called the HLW repackaging facility in PCSR Chapter 31: Decommissioning [Ref-11]) described in this section is based upon the system description identified as the preferred option in the reference report, Options for the Management of Dry Solid ILW [Ref-45].

The figures and process descriptions given in this and subsequent sections do not represent a final design for the UK ABWR. They represent facility requirements and capabilities in order to demonstrate that the waste management operations as described in the PCSR Chapter 18 sections 18.10 and 18.11 [Ref-7] are achievable.

The preferred final disposal package is the ILW 3m^3 box. An overview of an example SILW process and facilities is presented in Figure 11.4.1-1.

11.4.1 Facility Requirements

11.4.1.1 Waste Inventory and Characteristics

Dry solid HAW (HLW at arising, ILW at disposal) arises solely from the periodical removal of various non-fuel core components from the reactor. The waste stream to be managed comprises control rods and other solid HAW items:

- Control rods containing Hafnium (used for neutron flux control in the reactor on a day-to-day basis);
- Control rods containing Boron Carbide powder (used intermittently for start-up and shutdown;
- Low Power Range Neutron Monitors (LPRM);
- Short Range Neutron Monitors (SRNM);
- Traversing In-core Probes (TIP); and
- Neutron Source Units (NSU).

All of the dry solid HAW items will be neutron activated, with ^{60}Co, ^{63}Ni, ^{55}Fe and ^{54}Mn being the dominant radionuclides. The Hafnium control rods are the most highly activated components, with dose rates on contact on removal from the reactor in the order of 10's of Sieverts per hour. At arising, the solid HAW must be remote handled in order to be packaged.

11.4.1.2 Decay Storage Requirements

The radiogenic heat output of dry-solid ILW and the implications for the decay storage period is discussed in [Ref-45] and reproduced in Table 11.4.1-1.

Table 11.4.1-1: Radiogenic Heat Output of Dry Solid ILW Type with Time

Waste Type	Package	Mass	Radiogenic Heat Output (W)		Time decay storage period before packaging 200W limit	Time decay storage period before packaging 400W limit
			On discharge from Reactor	After 25 years of Time Decay Storage		
Hafnium control rods	Individual control rod	110 kg	87	3.29	22 years	~16 years
	$3m^3$ Box	3995 kg waste	3170	120		
Boron Carbide control rods	Individual control rod	90 kg	10	0.39	~7 years	~2 years
	$3m^3$ Box	3995 kg waste	452	23		
LPRM	$3m^3$ Box	2116 kg waste	229	8	1 - 2 years	0 year
SRNM	$3m^3$ Box	3825 kg waste	413	15	~ 6 years	~1 year
TIP	$3m^3$ Box	5737 kg waste	620	22	7.5 years	~3 years
NSU	$3m^3$ Box	5373 kg waste	581	21	~7 years	~3 years

Considering the radiogenic heat output from the dry solid ILW, it is apparent that site-based decay storage of the waste items prior to packaging in a $3m^3$ box will be required to ensure that the surface temperature limit is minimised to prevent stress corrosion cracking of the $3m^3$ box.

11.4.1.3 Storage in Steel Canister and Overpack in the Dry Spent Fuel Storage Facility

This concept is to store solid HLW (ILW after decay) in stainless steel canisters in shielded overpacks in a HLW Decay Storage Facility in a separate building co-located with the SFIS. Such storage systems are commercially available and are used in the USA.

Although it is expected that there will be low levels of contamination on the surface of the waste, grouting of the dry solid ILW during decay storage is not considered proportionate since the container provides robust containment and the physical nature of the waste itself is robust.

The storage system consists of the following components:

Non-Fuel Waste Container (NFWC): A stainless steel canister capable of holding between 25-50 control rods (if control rods are size reduced this may be approximately 150 control rods) or baskets of dry solid ILW. This is used for interim storage only and is not an approved GDF disposal package.

Transfer cask: Used for providing shielding and protection during loading and cross site transfer. This also facilitates transfer of the NFWC into the overpack.

Storage overpack: The overpack provides shielding and structural protection to the NFWC during interim storage. The overpack has variable shielding (up to ~760mm) depending on the limiting dose rate. The typical maximum size of an overpack is 150 tonnes, 6m tall and 3.4m diameter.

A proposed system for SF is given in section 11.6 and an identical process is anticipated to be used for wastes that bare HLW at arising.

The decay store will provide a safe storage environment for control rods and baskets of dry solid HLW (ILW following decay). The first import campaign to the decay storage would take place after 6 years of operations when approximately 28 baskets of dry solid HLW are transferred for storage. The first control rods will be received in +12 years of reactor operation in which 29 Hafnium control rods will be transferred to decay store. The maximum input will be in +36 years operations when 29 Hafnium control rods, 176 Boron Carbide control rods and approx. 14 baskets of solid HLW will be transferred to the solid HLW decay storage.

It is assumed that if dry decay storage is provided then any subsequent size reduction, treatment and repackaging of the solid ILW following decay in the SILW facility will also take place in a dry environment.

11.4.1.4 Repackaging to 3m^3 Boxes

Once the GDF is available, the decayed HLW, now ILW, will be transferred to an inspection / maintenance / repackaging facility for processing prior to placement into GDF disposal containers (e.g. 3m^3 boxes). It is assumed that a single process facility, with two process lines (one HLW/ILW and one SF), will be required.

The ILW and LLW BAT study [Ref-45] concluded that in order to be economical a dry solid ILW treatment and repackaging facility would have to package at least 10-15 boxes per campaign. This, coupled with the fact that there is a requirement to decay store the Hafnium control rods for a period of at least 22 years, leads to the conclusion that decay storage and a campaign packaging approach is the optimal way forward for the management of dry solid ILW.

An illustrative 3 campaign repackaging schedule is given in Table 11.4.1-2.

Table 11.4.1-2: Repackaging Campaign Information

Campaign	Date	Control Rod	Baskets of dry solid ILW
1	+37 years after reactor operational	234	452
2	+67 years after reactor operational	321	257
3	+85 years after reactor operational	87	0

It is noted that:

- The date for Campaign 3 is approximately two years after the aspirational date for site clearance, so may be brought forward for mixing with decommissioning wastes.
- 30 years between campaigns has a significant human factors issue (e.g. retention of SQEP staff, plant familiarity, plant mobilisation / mothballing etc.). Other options may need to be considered, for example, long-term decay storage with one campaign of waste processing at the end, whilst also ensuring compliance with LC32.).
- Processing of operational dry solid ILW will result in about 31 off $3m^3$ boxes being produced for a single ABWR site. The number of waste packages produced is heavily influenced by the effectiveness of the size reduction and packaging processes. Further work at the site specific stage is required to confirm that the expectations for size reduction and packaging are practical.

  The future site operator will determine the optimal (BAT) repackaging regime with due consideration of operational and decommissioning solid HLW and ILW arisings.

Potential optimisation strategies that include consideration of decommissioning waste management requirements are outlined in 11.4.6.

11.4.1.5 Summary of the solid HLW at arising, ILW at disposal Process

A summary of the dry solid HLW (ILW after decay storage) management process and facilities from SFP to dispatch to the GDF is presented in Figure 11.4.1-1. The option remains open to the licensee to dispatch the final waste packages directly to the GDF (preferred option) or to transfer the package to the ILWS, if necessary, for package management prior to consignment off-site.

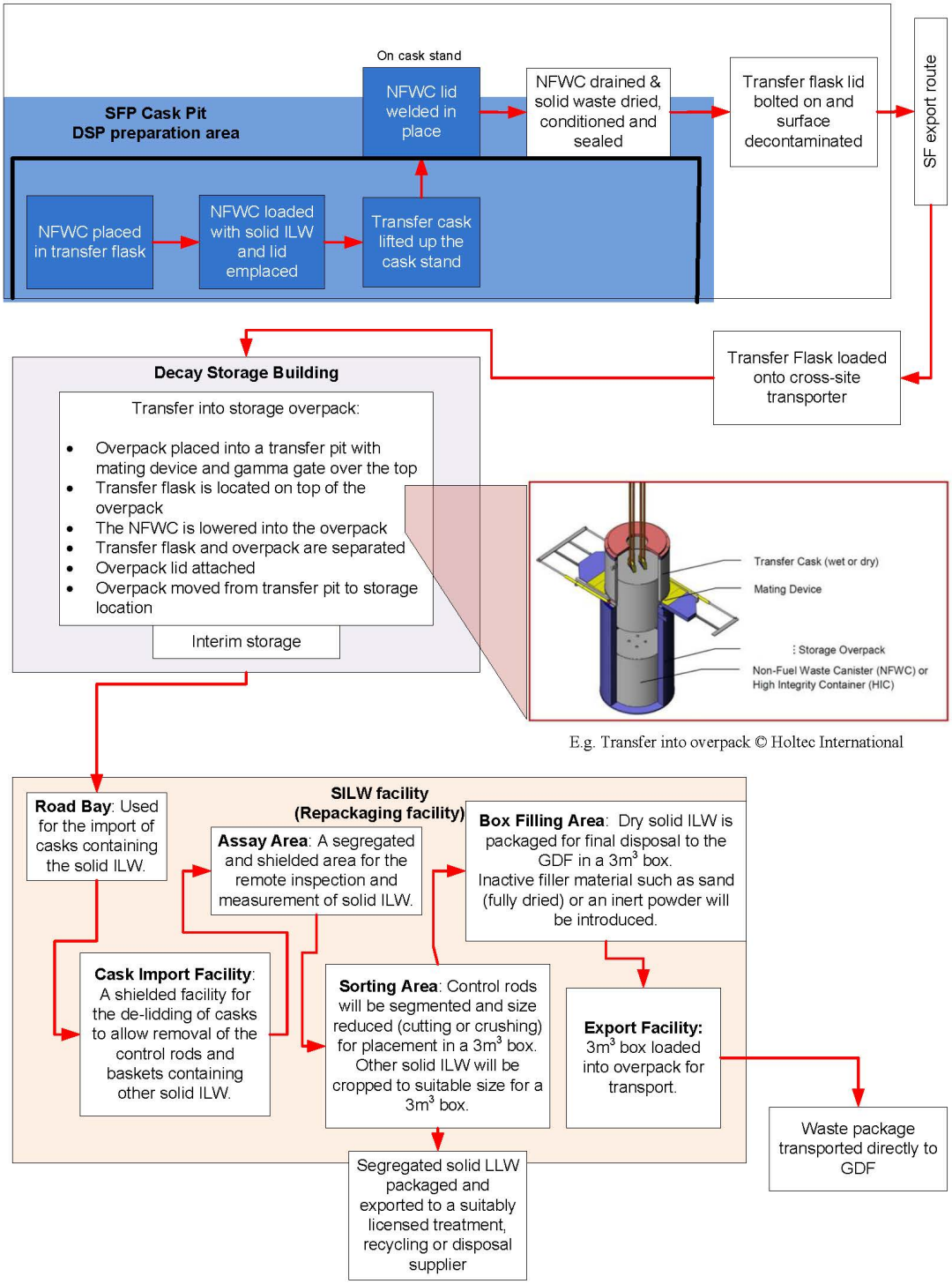


Figure 11.4.1-1: Example Solid HLW (ILW after decay) Management Process and Facilities

11.4.2 Secondary Wastes

The production of secondary waste will be minimised as far as practicable. Dry-solid wastes will be segregated at source, packaged and exported to the SWF. The decay stored ILW repackaging facility will have the capability to assay, buffer store and consign its own wastes for off-site treatment or disposal once the SWF has been decommissioned.

SFP wet solid wastes arising from the FPC are routine and will be managed in the wet-solid waste facilities described in Sections 11.2 and 11.3.

The preferred solution for the SILW facility is to use a dry treatment process. A dry process would enable the secondary solid wastes to be treated within the SILW facility itself or the SWF. However, sensitivity analysis indicates that the selection of a dry treatment process over a wet treatment process that could include a cutting pool wasn't robust. If, through detailed BAT selection, the future UK ABWR site operator chooses a wet treatment solution, the resultant wet-solid wastes from a cutting pool conditioning system will require independent water and waste treatment facilities following decommissioning of the Rw/B.

11.4.3 Gaseous and Liquid Discharges

The SFP gaseous and liquid waste management system operation is routine (see sections 8 and 9).

The decay storage building will have zero discharge implications in normal conditions due to the robust, undisturbed containment of the waste.

The SILW facility will require HEPA filtration, control and monitoring of gaseous discharges. The final design of this facility will follow the future site operator's detailed BAT study. An option for optimisation (see section 11.4.6) is to store the ILW until the SF is retrieved for packaging. This optimised approach, as well as allowing the ILW radioactivity to decay, would lend itself to the design of shared facilities and discharge routes.

11.4.4 Process and Waste Product Monitoring

The Radioactive Solid Wastes Monitoring Requirements document [Ref-10] discusses and presents the SILW facility monitoring requirements in more detail.

Sections 11.8 and 11.9 discuss the requirement for a waste tracking and management system and a QA system.

11.4.5 Design Life and Decommissioning

The SILW decay storage and repackaging facilities have yet to be designed beyond that presented in the referenced optioneering reports. The design life will be appropriate to the facility requirement based on reactor operations of a period of 60 years followed by support to site decommissioning for a further 30 years.

11.4.6 Optimisation Opportunities

To gain the greatest benefit from the use of storage overpacks, it is proposed that instead of a Three-Campaign model, all SILW (HLW at arising) is stored in a dedicated HLW storage facility, co-located with the spent fuel store, or if space is limited, in its own area until the GDF is available to receive ILW packages. At this point, the majority of the radioactivity will have decayed away resulting in the subsequent treatment of the ILW having a lower dose update implication and potentially enabling more effective segregation at size reduction.

Section 10.9.2 identifies the requirement to construct a Hot Cell for SF inspection and repackaging of

decay stored HLW prior to the SFP being removed from service during decommissioning. The final BAT HLW/ILW repackaging strategy will be decided by the future site operator based upon international operational experience and methodology development.

An opportunity exists using this option for direct disposal of the NFWC to the GDF after an appropriate storage period. At present, the NFWC is not an approved disposal container and as such would require engagement with RWM Ltd at an appropriate time to determine if this would be feasible. If this were the case, then a treatment facility would not be required, leading to significant reduction in radiation dose uptake and cost savings. The advancement of these opportunities will be dependent upon future demonstration of BAT by the site operator and acceptance by the UK regulators and RWM Ltd.

11.5 ILW Store (ILWS)

This section provides an overview of an example ILWS. The figures and process descriptions given in this and subsequent sections do not represent a final design for the UK ABWR. They represent facility requirements and capabilities in order to demonstrate that the waste management operations as described in the PCSR Chapter 18 section 18.11 [Ref-7] are achievable.

The ILWS receives processed and packaged operational wet-solid ILW (see Section 11.3) from the Rw/B, processed and packaged decommissioning dry-solid ILW and provides interim safe storage until the GDF becomes available. The preferred option for decay stored HLW (ILW after decay) is to repackage into final disposal packages (typically $3m^3$ boxes) once the GDF is available to receive them, and dispatch directly to the GDF from the repackaging facility. However, the option remains to the future licensee to transfer waste packages from the repackaging facility to the ILWS should there be a requirement for package management buffer storage during the repackaging and dispatch process.

The use of SCVs in the WILW ensures that waste packages received at the ILWS are free from surface contamination. The ILWS is based on passive safety principles.

The ILWS will require the following storage areas:

For 3 m^3 drum storage:

- Shielded storage locations for $3m^3$ drums.
- Allocation of quarantine storage positions for $3m^3$ drums.
- Allocation of storage positions for $3m^3$ drums arriving in SCVs from the WILW.
- Provision of a $3m^3$ Dummy Drum for condition monitoring.
- Allocation of $3m^3$ drum shuffling positions required during periodic inspections.
- Provision of a shielded segregation barrier between the $3m^3$ drum and $3m^3$ box sections of the store.

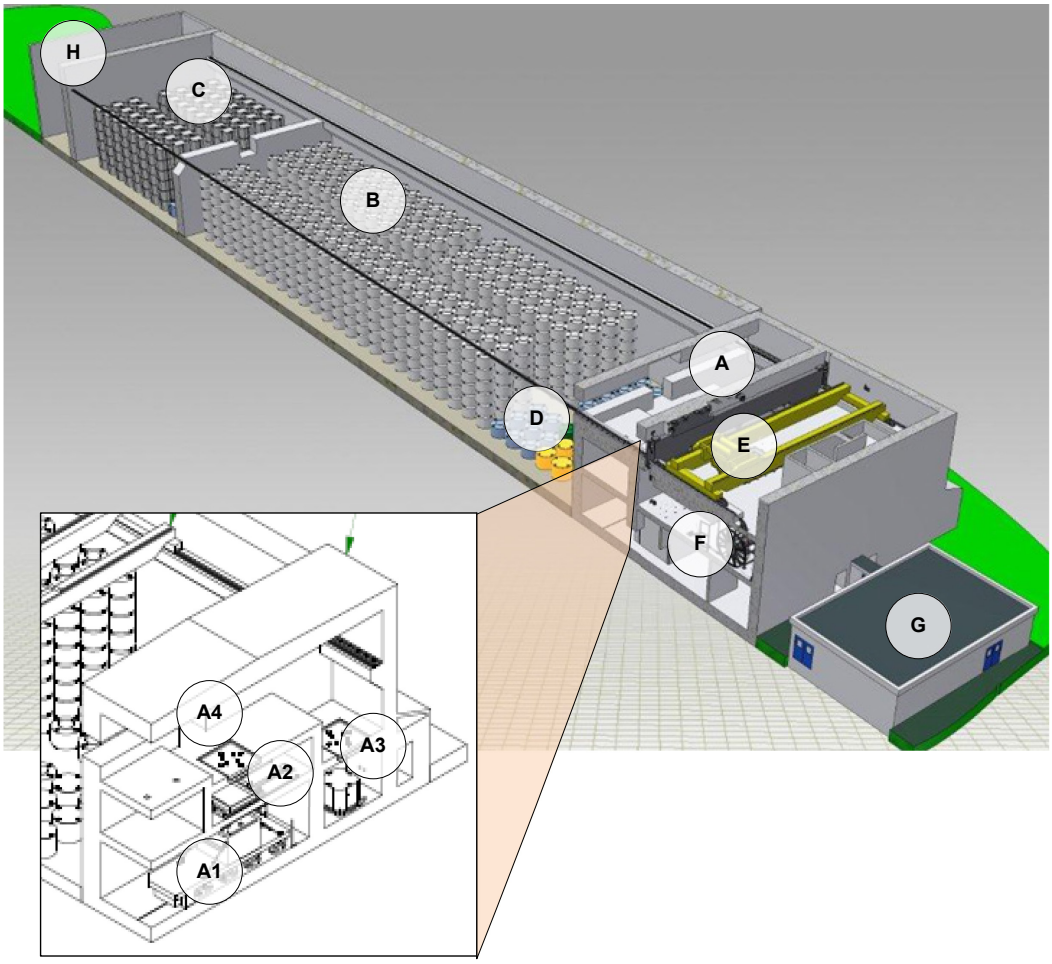
For $3m^3$ box storage:

- Shielded storage locations for $3m^3$ boxes.
- Allocation of quarantine storage positions for $3m^3$ boxes.
- Provision of a Dummy $3m^3$ box for condition monitoring.
- Allocation of $3m^3$ box shuffling positions required during periodic inspections.

All ILW packages will be accessible to allow retrieval at any time during interim storage for inspection, assay and remediation as required.

11.5.1 ILWS Layout

The layout of an example ILWS is illustrated in Figure 11.5.1-1. The figure does not present a final design for the UK ABWR; it represents the facility requirements and capabilities in order to demonstrate that the waste management operations are achievable.



A	Service block	C	3m^3 box storage area
A1	Package Receipt Bay (PRB)	D	Quarantine and SCV storage
A2	Package Identification Room (PIR)	E	Package Handling Machine (PHM)
A3	Package Inspection Cell (PIC)	F	Ancillary and maintenance facilities
A4	Access to storage area	G	Welfare block
B	3m^3 drum storage area	H	HVAC

Figure 11.5.1-1: Example ILWS Layout

11.5.2 ILWS Processes

The ILWS processes are illustrated in Figures 11.5.2-1 and 11.5.2-2.

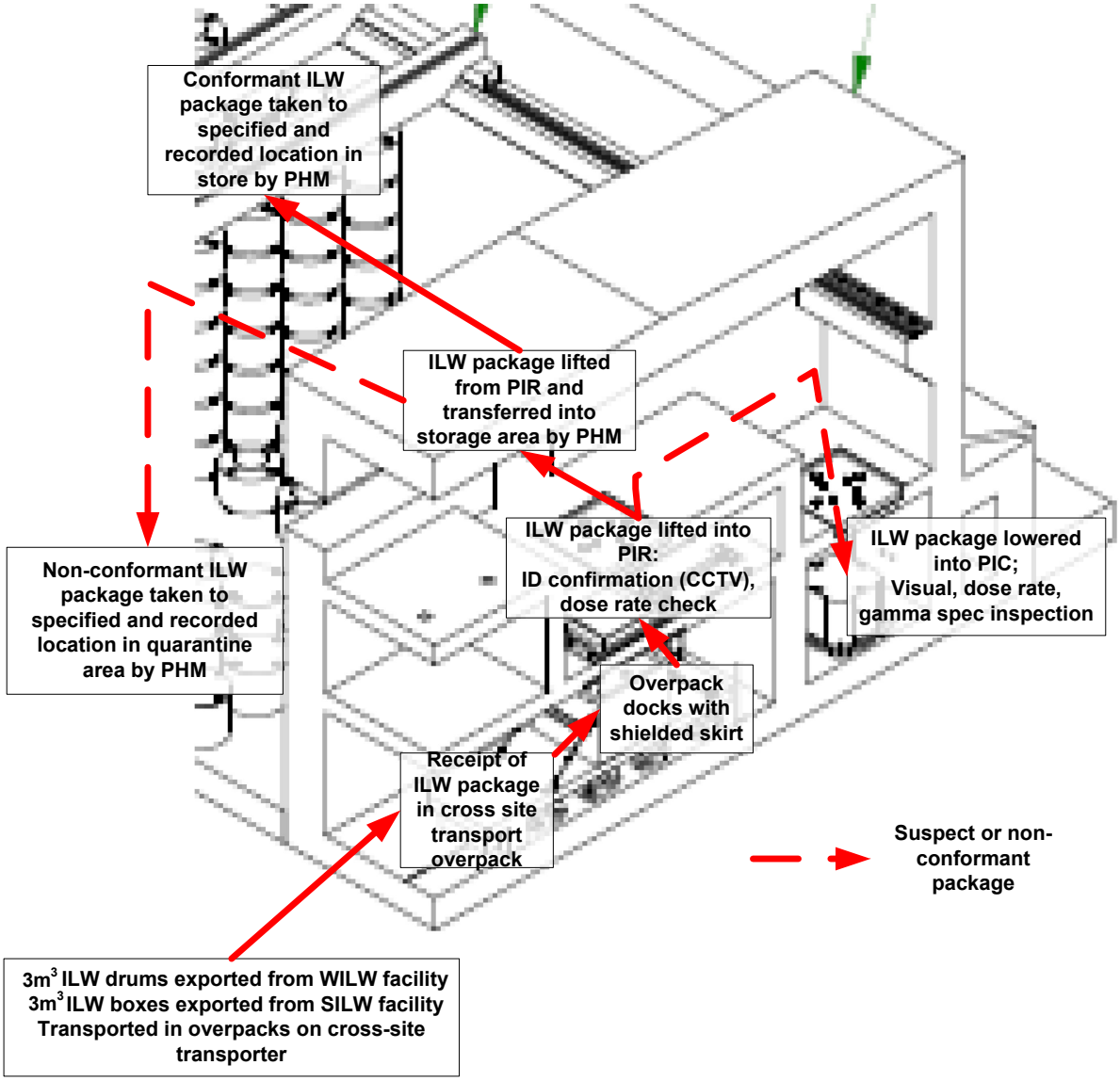


Figure 11.5.2-1: Example Package Receipt Process

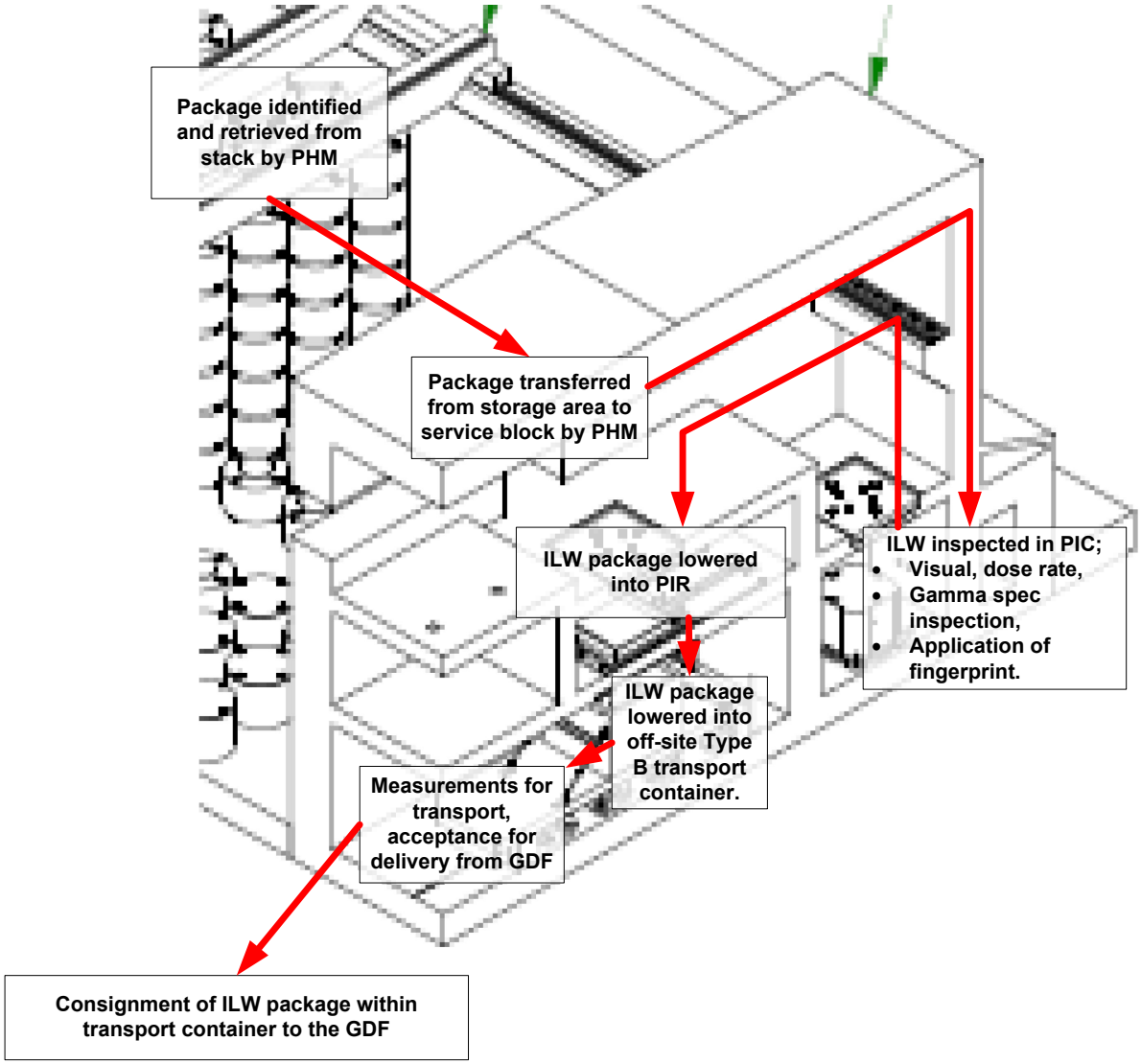


Figure 11.5.2-2: Example Package Dispatch Process

11.5.2.1 Waste Package Periodic Inspection

The ILWS provides facilities for waste package periodic inspections during the storage period. The PIC undertakes all package inspections necessary during the storage period at the ILWS and incorporates the following:

- A turntable enabling rotation of the waste package.
- A removable shielded roof hatch on exit from the cell.
- Interlocked personnel access doors into the PIC.
- A radiological assay system to provide an accurate radiological fingerprint of the waste package.
- A gamma monitoring system to provide interlock restrictions to access doors when high area dose levels are detected, preventing personnel access.

- A closed circuit television (CCTV) system to relay images of the waste package and internal identification room activities to the facility control room during remote working.
- A cell lighting system to provide appropriate lighting levels for maintenance activities, the CCTV system and viewing through the shielded window.
- A shielded window to enable the operator to have a suitable view from the remote operating position.
- Master Slave Manipulators to remotely complete surface swabbing of the package and participate in turntable recovery operations.
- A posting facility to get clean swabs into and used swabs out of the cell during surface contamination checks.

Inspection of stacked packages in the storage area may be achieved with the provision of a Package Inspection Camera Deployment System.

Dummy packages will be deployed within the ILWS and their inspection will inform the facility operator of the condition of waste packages.

The PIC may be used to inspect any suspect package on receipt to the ILWS and is used to monitor all packages before dispatch.

11.5.3 Secondary Wastes

Secondary wastes will be generated in support of inspection / maintenance / replacement requirements to ensure that plant is functional and available during the storage period. However, the design of the ILWS aims to avoid the generation of radioactive waste: received packages are free from external contamination and there is no facility for repackaging waste.

All waste items will be monitored in the health physics room adjacent to the main change room in the ILWS and segregated prior to removal; any contaminated items will be decontaminated and categorised prior to being routed to the SWF for disposal; out of scope items will be segregated and consigned to an appropriate waste route following the waste hierarchy principles.

HVAC components and HEPA filters associated with the vault system are located in plant rooms adjacent to the vault end wall. Items removed will be locally checked for contamination, segregated and double bagged where appropriate prior to removal to the ILWS loading bay for onward disposal.

11.5.4 Gaseous and Liquid Discharges

The vault extract and recirculation systems will have appropriate HEPA filtration, monitoring, and discharge flues to protect the site worker, public and environment. In normal operation, the containment offered by the waste containment packages ensures that gaseous radioactive discharges are prevented.

Non-radioactive liquid effluent (hand washing and toilets) from within the welfare block will be fed directly to the site main drainage system.

Any potentially active liquid arising from the ILWS (change room emergency shower / washing facilities) will be low volume and low radioactivity. The water will be collected, monitored and subsequently transferred to the appropriate LWMS for treatment and discharge.

11.5.5 Storage Environment Control

The vault is supplied with an HVAC system which will maintain the environment at specified levels of

temperature and humidity to control the potential for condensation and minimise the presence of hydrogen and chlorides.

11.5.6 Design Life and Decommissioning

The ILWS has a design life of 115 years. The design of the ILWS aims to avoid the generation of radioactive waste: received packages are free from external contamination and there is no facility for repackaging waste. The wastes to be generated at decommissioning are assumed to be exempt and disposable through conventional waste routes following the waste hierarchy principles.

11.6 Spent Fuel Interim Store (SFIS)

Together, the Generic PCSR Chapter 19: Fuel Storage and Handling [Ref-46] and Chapter 32: Spent Fuel Interim Storage [Ref-47] describe the management of SF:

PCSR Chapter 19 describes the handling of SF from the reactor to export from the R/B and includes:

- Section 19.6 Fuel Handling Machine.
- Section 19.7 Reactor Building Overhead Crane.
- Section 19.8 Spent Fuel Storage Facility; the SFP, the Cask Pit, the SF storage racks and the SFP gates.
- Section 19.10 Spent Fuel Export Systems; cask stand, transfer cask, canister, associated canister preparation systems and the Low Profile Transporter.

The scope of Chapter 19 ends, and the scope for Chapter 32 starts, at the R/B doors completing SF export from the building. Chapter 32 considers any operation involving SF from outside the reactor building door to disposal of fuel off-site.

PCSR Chapter 32 presents a SFIS design based on current commercially available technology as a concept SFIS system, but which still allows the licensee to take advantage of adopting relevant good practice and technology which may become available in the future.

The Generic PCSR Chapter 32: Spent Fuel Interim Storage [Ref-47] and references therein describe the SFIS with the purpose of providing a concise description of the SFIS concept design and high level safety case including, amongst others, the following:

- Demonstrate that the concept for SFIS presented within GDA is feasible
- Demonstrate that the SF generated by the station can be safely stored on site and repackaged
- Demonstrate that risks are capable of being reduced ALARP.

This section describes the facilities and processes for SF management based on the PCSR Chapters 19 and 32 and references therein.

11.6.1 Working Assumptions

A number of working assumptions are made in order to demonstrate that a SFIS system can be deployed within the generic UK ABWR design and that nuclear safety issues are adequately considered for the GDA process. Spent fuel management and storage has nuclear safety as the overriding consideration. By ensuring the nuclear safety of the SFIS methodology and facility design, storage conditions are managed and discharges to the environment minimised and controlled. Therefore, by assuring nuclear safety, environmental protection is also assured.

Justification of the final design decisions will be made in the site licensing process. The working

assumptions are as follows:

- The fuel storage canister will be similar in design to the MPC design supplied by Holtec International.
- The canister will hold up to 89 spent fuel assemblies.
- Number of canisters: 108 (9600 SF assemblies).
- The transfer cask and concrete overpack designs will be commercially available designs, for example, similar to those supplied by Holtec International.
- Transfer of the canister between the transfer cask and the concrete overpack will take place at the SFIS.
- Dry canister & overpack storage will be up to a maximum of 140 years.
- Fuel type: BWR fuel assembly (GE14).
- Burn up: 55 GWd/tU (maximum bundle average)
- Pool cooling period: 10 years (average).
- The stored canisters in overpacks will be accessible to allow retrieval at any time during interim storage for inspection, and remediation as required.
- Repackaging of SF into an approved disposal container will be required after interim storage and before disposal.

11.6.2 Canister Packed in Concrete Overpack Storage System

A typical concrete overpack storage assembly is illustrated in Figure 11.6.2-1 [Ref-48]. The air inlet vents at the bottom of the overpack and the exit vents at the top allow natural convection of air through the space between the canister and the overpack to provide a passive heat removal system during storage. The fuel storage equipment, including the canister and overpack system, are described in PCSR Chapter 32 [Ref-47]

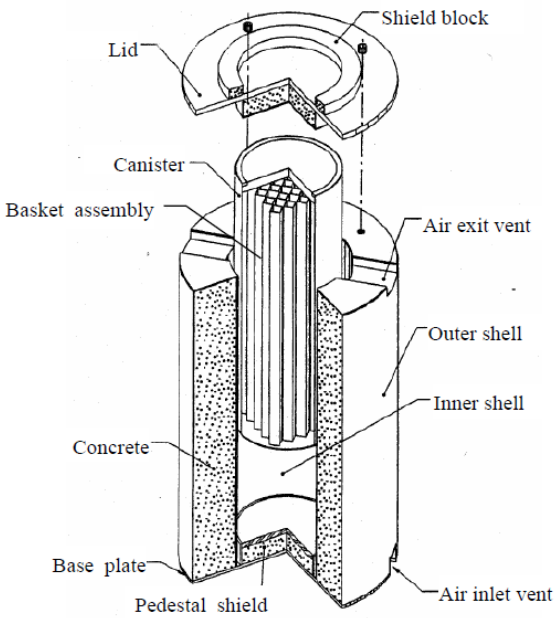


Figure 11.6.2-1: Schematic View of an Example Canister and Concrete Overpack Storage Assembly

11.6.2.1 Canister

The canister stores spent fuel during the lifetime of the SFIS process. A fuel load of 89 assemblies per canister is assumed at this stage of the GDA process. The canister will also be capable of storing a damaged fuel assembly. The canister consists of two discrete components; the enclosure vessel and the fuel basket. The enclosure vessel forms the containment barrier while the fuel basket maintains fuel geometry within the vessel. The canister lid is fitted with vent and drain ports that are used to remove moisture and air from the canister at loading and to backfill the loaded canister with an inert gas.

The functions for the canister are:

- Containment: the canister provides a containment barrier for the lifetime of SFIS once the lid to shell weld is completed and all vent and drain ports are sealed.
- Cooling: the canister is designed to be pressurised with an inert gas and maximises heat transfer from the fuel to the canister outer wall.
- Criticality: the basket is designed to maintain sub-criticality.
- Shielding: minimal claims are made on the canister shell to provide shielding. Shielding is instead provided by the transfer cask and concrete storage overpack during export and storage operations.
- Handling / retrievability: lifting features allow handling of the canister. The canister is designed to withstand credible canister or cask drop faults.

Environmental protection during the interim storage phase is assured by the canister through the above safety functions by: isolation of the SF (containment), maintaining safe and controlled storage conditions (cooling, criticality, and ability to withstand drops) and the ability to be repackaged if required (retrievability).

11.6.2.2 Transfer Cask

The transfer cask will be a rugged, heavy-walled cylindrical vessel designed to contain a canister. It will be used to transfer the loaded canister during the SF export process and to transfer the canister into a concrete overpack. The functions for the transfer cask are:

- Shielding: the primary purpose of the transfer cask is to provide shielding when fuel is held in the canister.
- Protection: the transfer cask provides physical protection to the canister against the consequences of a dropped load.
- Cooling: the transfer cask provides an annular gap between the canister and the inside wall of the cask to allow passive cooling of the canister.
- Handling / retrievability: suitable lifting features will be included to facilitate the handling of the transfer cask.

Environmental protection during canister movement is assured by the transfer cask through the above functions by: maintaining safe and controlled movement conditions (cooling and shielding).

11.6.2.3 Concrete Overpack

The concrete overpack will be used to store the canister at the SFIS facility. It will consist of a heavy-walled, multi-layered, cylindrical vessel constructed of shielding material. The vessel will have a top annular lid and thick baseplate.

The functions for the concrete overpack are:

- Shielding: the primary purpose of the concrete overpack is to reduce dose to operator, public and the environment during interim storage ALARA.
- Protection: the concrete overpack provides physical protection to the canister during interim storage.
- Cooling: vents at the base and top of the overpack allow for ingress of air and passive cooling of the canister surface by natural convection.
- Handling / retrievability; the canister is retrievable from the concrete overpack.

Environmental protection during storage is assured by the overpack through the above functions by: maintaining safe and controlled storage conditions (protection, cooling and shielding). Stored SF is retrievable.

11.6.3 Facility and Process

The outline handling process of SF in the SFP, followed by transfer and storage in concrete overpacks is described in PCSR Chapter 19 [Ref-46] and Chapter 32 [Ref-47] and is illustrated in Figure 11.6.3-1.

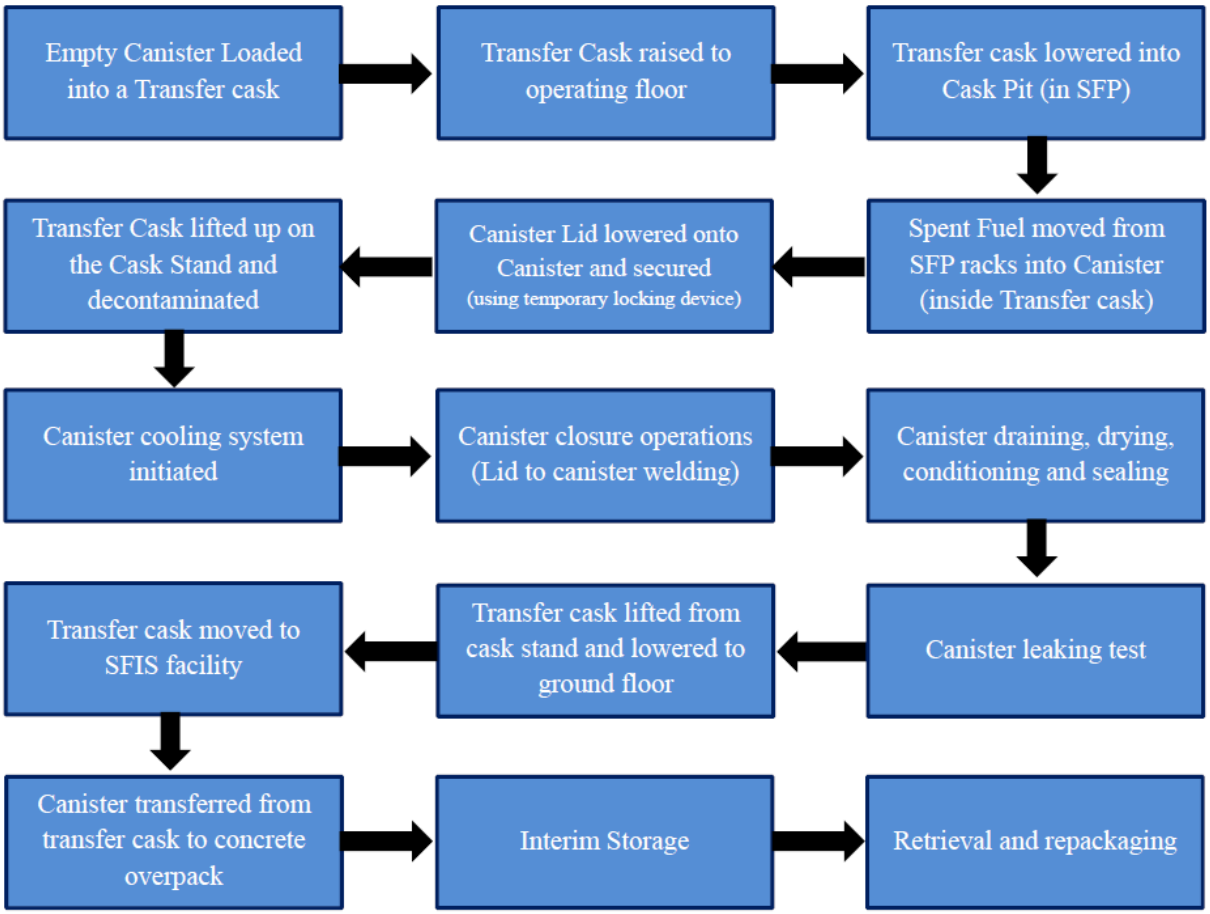


Figure 11.6.3-1: Sequence of Key SF Management Operations at Completion of Cooling Period in SFP

11.6.3.1 SFP, including Cask Pit

To one side of the SFP is a cask pit. The pit forms part of the SFP and consists of three concrete walls protruding from the SFP wall, creating a separate 'bay' to the main SFP. The pit is large enough for a transfer cask to be lowered within it. A gap is provided in one of the cask pit concrete walls, large enough

for a fuel assembly to be moved from the main SFP bay into the cask pit using the fuel handling machine. The cask pit is separated from the SFP by sealed gates during cask handling to prevent significant water level changes in the SFP as the cask is lowered into or removed from the cask pit. Operations carried out within the cask pit, including on the cask stand are outlined in Figure 11.6.3-1.

11.6.3.2 Transfer Cask Transporter

The transfer cask transporter is used to transfer the cask from outside the reactor building to the SFIS facility and place it on the mating device. The cask transporter is a multi-wheeled or tracked, multi directional vehicle capable of handling loaded transfer casks / storage overpacks.

11.6.3.3 Spent Fuel Interim Storage Pad and Storage Facility

Concrete overpacks will be stored on a pad within a lightweight building. These will protect the canisters from external hazards and harsh environments. The detailed design for the pad and interim storage building will be site specific and developed by the future site operator during site licensing and is outside the scope of GDA.

The key functions of the interim storage location include:

- Provide a suitable storage space to house all the SF generated during operation.
- Provide a transfer area to facilitate the transfer of the loaded canister to/from the concrete overpacks.
- Protect the loaded concrete overpacks from the environment to an appropriate level while allowing sufficient ambient air flow to support cooling.
- Allow for monitoring, testing and potential recovery actions on the loaded concrete overpacks.

The location for the SFIS facility will be a site specific decision. It will be chosen to minimise dose at the site boundary as far as practicable (e.g. through maximising the distance to the site boundary). Shielding is provided by the concrete overpacks.

Safe, secure storage of the SF in canister and concrete overpack will be for a maximum period of 140 years. Regular monitoring of the concrete overpacks will be carried out to detect degradation of the storage system and to ensure adequate cooling is provided by inspecting cooling vents for blockages.

11.6.3.4 Repackaging Facility

At the end of interim storage the SF will be removed from the overpack and canister and transferred into final disposal containers. The current reference disposal container, subject to RWM acceptance, is the KBS-3 canister. Such an operation, many decades after reactor closure, will require a dry transfer cell facility to move spent fuel assemblies from the storage canisters to the final disposal containers. The assumption held in the optioneering study is that a dry transfer facility, which will also serve as the eventual repackaging facility, will be available for inspection/transfer of spent fuel prior to the reactor building ceasing operations. While the reactor building SFP is operational, it is assumed that inspection/repackaging of spent fuel would occur in the SFP facility.

The process and design of a future dry transfer / repackaging facility will use BAT, based on international operational experience and best practice, ensuring environmental protection and nuclear safety. Key features of the repackaging facility are likely to include:

- Shielding.
- Containment and ventilation.
- Laydown area for the concrete storage overpack or transfer cask.

- Equipment to allow removal of the canister from the concrete storage overpack or transfer cask (if required).
- Canister opening equipment.
- Transfer equipment: SF from canister to repackaging system.
- Pre-handling inspection equipment to confirm retrievability of canister and SF.
- Loading area and equipment: SF to final disposal container.
- Loading area and equipment: disposal container to transport package.
- Dispatch bay for consignment of the loaded transport package to the GDF.
- Waste processing area.

Radiation shielding and containment functions could be achieved by providing a hot cell in which to carry out all operations that handle a canister or SF directly.

The design of the repackaging facility is not foreclosed to the future licensee by the assumptions set out within the GDA. Development of a repackaging facility design will not be completed during GDA as it will not be required for a number of years into SFIS operations and continued development of the facility should not be foreclosed.

The preferred option for the management of HLW generated during operations and decommissioning is also decay storage in a dry canister and overpack system. Following storage awaiting the availability of the GDF, the HLW will have decayed to ILW and will require repackaging. It is anticipated that the SF inspection and repackaging hot cell will have a second process line for the repackaging and export of decay stored HLW. See also section 11.4.

11.6.4 Secondary Wastes

Solid secondary wastes will be generated as a result of the decontamination of the storage canister lid and the transfer cask. Processing equipment from canister and overpack loading operations may be internally and / or externally contaminated and classified as radioactive waste on replacement or final disposal.

At the end of interim storage, the concrete storage overpacks, and canisters if fuel is removed and repackaged for disposal will become radioactive waste. The repackaging facility may also become contaminated, resulting in solid radioactive waste during operation and decommissioning.

The future design of the SFIS will consider the requirement for a solid waste management system post R/B and SWF decommissioning.

11.6.5 Gaseous and Liquid Discharges

The containment and passive cooling system of the SFIS will not produce radioactive gaseous discharges. However, it has been identified in 11.6.3.4 that the repackaging facility hot cell requires a suitable HVAC system. Dry solid waste such as HEPA filters from the repackaging facility would be managed as LLW.

The SFIS design is a dry storage system. Radioactive liquid discharges, other than those from personnel wash facilities, are not expected.

11.6.6 Design Life and Decommissioning

The working assumption during the site operational phase is that SF will be stored in the SFP for 10 years prior to transfer to the SFIS. The decommissioning strategy [Ref-11] identifies the SFP to be empty following the export of the last batch of fuel, 10 years after removal from the reactor.

Dry canister & overpack storage will be for a maximum of 140 years. The future design of the SFIS will consider the requirement for a solid waste management system post R/B and SWF decommissioning.

The SF inspection and repackaging facility will be the last facility to start decommissioning and will generate a quantity of radioactive contaminated waste. As well as providing for the management of SF repackaging waste arising, the facility design will include provision for the management of its own decommissioning LLW and potentially ILW decommissioning waste.

11.7 Waste Packages and Transport Systems

RWM has developed and published a number of specifications and guidance documents [Ref-28] which define the requirements for a range of standard waste packages. These are largely based upon the use of thin walled stainless steel containers within which a wasteform is created by combination of the waste either with a cement powder blend for water based slurries or infiltration of a cement grout for solid waste items. These specifications are based upon a GDF design and waste packaging proposals submitted by waste producers to RWM are assessed against this design using a well-developed LoC process. This process has three stages for package endorsement comprising 'conceptual', 'interim' and 'final' stages; the last stage providing evidence of disposability to the ONR to enable them to grant a Licence Instrument to the waste producer for implementation of waste packaging. These packages would need to be transported within a reusable shielded transport container. This combination is usually classed as a Type B transport package under the IAEA Transport Regulations.

Currently available LLW disposal facilities define acceptable waste packages and transport containers in their waste acceptance criteria. LLWR Ltd contract with various LLW treatment and disposal suppliers and their waste acceptance criteria reflect, in general, the criteria of those suppliers. The LLWR Ltd waste acceptance criteria have therefore been used as a representative point of reference when identifying typical waste packages within the UK ABWR waste treatment and storage facility conceptual design process.

The reference waste packages referred to in the facilities' example designs are listed in Table 11.7-1 alongside their respective facility.

Table 11.7-1: Summary of Waste Packages and Containers

Package / container	Facility
Non-Fuel Waste Canister (NFWC)	SFP, SFIS
Transfer cask	SFP, SFIS
Concrete overpack	SFIS
Disposal container (KBS-3)	SF repackaging facility
Type B transport package	SF repackaging facility
$3m^3$ drum	WILW, ILWS
$3m^3$ box	SILW, ILWS

Package / container	Facility
3m^3 drum SCV	WILW, ILWS
3m^3 box SCV	SILW, ILWS
IP-2 TC01 Package	SWF
IP-2 TC02 Package	SWF
IP-2 TC03 Package	SWF
TC02 stillage type S1	SWF
TC02 stillage type S3	SWF
IP2 TC19 Package	SWF
WB-1 Waste Box	SWF
Berglof box	SWF
S1 Stillage lifting Frame	SWF
S3 Stillage Lifting Frame	SWF

In order to assess waste packaging arrangements proposed during the GDA process RWM has used a 'pre-conceptual' assessment process, based upon the LoC process, to provide a Disposability Assessment which is sufficient for the GDA process to show that waste packages generated by the subject design will be disposable (see Section 13).

11.8 Waste Tracking and Management System

The UK ABWR site will feature a radioactive waste tracking system. The waste tracking system will be capable of tracking radioactive waste streams, containers used for on-site transfer of waste between facility and final waste disposal packages throughout the site.

The waste treatment and storage facilities described in this section are based on the assumption that all waste packages are marked with a unique alphanumeric characters identifier. The alphanumeric characters are machine optically readable. For final waste disposal packages the alphanumeric characters are indelibly marked on the containers and are suitable for the lifetime use of the package.

Part of the alphanumeric characters provides a means of identifying the type of waste package and its contents.

The waste tracking system can:

- Track empty waste packing containers within the facility from the point of entry into each facility, i.e. the waste package has been logged onto the system.
- Track filled waste packing containers within the ILWS.

- Track empty and filled packing containers within the processing facility until the point of exit.
- Provide information of filled LLW & ILW packages. The LLW and ILW waste information shall include but not be limited to the following:
    - Broad description of the waste material, i.e. metallic solids, filters, contaminated personal protective equipment etc.
    - Radioactivity level in Becquerels.
    - Type of radioactive isotopes present.
    - A link or data to the container manufacturing record.

11.9 Quality Assurance (QA) Records

Traceable QA records associated with each individual waste package (210 litre drum, Berglof box, WB1 waste box, TC01 HHISO, TC02 HHISO and TCO3 THISO, $3m^3$ drum, $3m^3$ box) will be assembled and retained throughout the manufacturing, assembly, loading, transfer, receipt / storage, periodic inspection and final export from the relevant facility.

Typically individual waste package QA records will be appropriate to satisfy site licence conditions, environmental permit requirements and disposal facility acceptance criteria. The records include, but are not limited to, the following:

- Unique package identification number,
- Unique stillage reference numbers where appropriate,
- Description of waste contents (including quantity where appropriate),
- Source of waste,
- Total package mass,
- Radiological information (contents radioactivity, surface contamination levels and final Assay records),
- Supplier Certificate of Conformity.
- Details of any periodic inspections during the interim storage period,

It is the responsibility of the consigning, donor facility to ensure that all required quality data is available and that waste packages and their transfer between facilities will be accepted by the receiving facility and compliant with site procedures. Non-compliant packages (non-compliance includes missing quality data) will be returned to the consigning facility.

Logging of the waste package locations will be performed by the facility operator. On receipt at the facility the package unique number will be read from the package using an Optical Character Recognition handheld bar code reader. This number will then be used to confirm that the correct QA records accompany the waste package from the donor facility. If the QA records are not available (e.g. incomplete data on database, illegible or missing label) then the package will be returned to the donor facility. In the exceptional circumstances that the consigning facility is unable to accept the returned waste package, the following facilities may be used for prompt management of the suspect package:

- The SWF glovebox inspection unit described in section 11.1.2.2;
- The ILWS quarantine area identified in section 11.5.1. Quarantined packages will be assessed and managed on a case by case basis prior to dispatch from the ILWS.

The package identification and location within the site facilities will be recorded in an electronic database as part of the site wide waste tracking system. The site waste tracking system will keep the QA records from the donor facilities along with the records of the package storage location until the waste is dispatched

from site. Records of all waste packages shall be retained for the life of the plant or until the waste is received into the appropriate disposal facility, whichever is longer.

12. Development of an Integrated Waste Strategy

The requirements for an IWS have been developed by the NDA [Ref-49] for the management of legacy wastes on operational sites or those undergoing decommissioning. It has also been adopted for the permitting process for new reactors to ensure compliance with UK policy. To support the production of an IWS appropriate to the GDA process, the Environment Agency (EA) and ONR have provided guidance on their expectations of IWS content through the Regulatory Query (RQ) and Regulatory Observation (RO) process for previous new reactor design GDAs. These sources indicate that a successful GDA IWS document will provide the following information:

- A clear identification of what wastes will need to be managed (both radioactive and non-radioactive);
- A description of how these wastes are to be managed now and in the future, taking account of the full waste lifecycle;
- A demonstration of how the strategy delivers against national policy and strategy;
- Signposting to key underpinning and justification information in an effective and accessible way; This will highlight references where they exist or describe the process where development is needed;
- An identification of future problems and/or gaps, and the solutions to address them;
- A demonstration of how the IWS may be implemented and how it factors into decision-making processes;
- A demonstration of how it is an integral part of meeting regulatory requirements for waste management;
- An accessible strategy to inform stakeholders.

An IWS appropriate to the GDA process has been produced by Hitachi-GE [Ref-4] which provides an overarching description of waste strategy. The IWS references to, and is supported by, detailed strategy documents such as this RWMA document. The GDA IWS is a live document which has been reviewed and updated at regular and appropriate intervals during the development of the GDA. This RWMA document, with the GDA IWS, allows for a site-specific IWS to be subsequently developed at a later stage which will then be subject to periodic review and update.

13. Disposability

13.1 LLWR Acceptance in Principle

LLWR Ltd. offers a well-recognised service for the whole UK Nuclear industry. It is currently adopted by many operational sites in the UK and also by the legacy sites. However, there are a number of other facilities which can be used for waste disposals which are not listed in this document. The references to LLWR are assumed for GDA to enable the obtaining of an ‘Acceptance in Principle’ for management/disposal of VLLW and LLW based upon the services undertaken by LLWR Ltd. The LLWR treatment and disposal routes are representative of the LLW treatment and disposal market and used to illustrate the availability of treatment options.

A letter from the LLWR giving 'Acceptance in Principle' for the VLLW and LLW presented in the previous issue of this document has been received by Hitachi-GE [Ref-50], [Ref-51].

Conditions noted in the letter refer to the future time of waste arising and include:

- New Waste Enquiry Forms will be required to be submitted at the time of waste arising,
- Treatment / Disposal at the LLWR is supported by a suitably underpinned BAT case,
- The waste complies with the Waste Acceptance Criteria in force at the time and meets the UK policy for the long term management of solid LLW (<4GBq/t alpha and <12GBq/t other radionuclides),
- The wastestream is adequately characterised, and
- The wastestream possesses a UK Radioactive Waste Inventory identifier.

Hitachi-GE have re-assessed the waste specific activities as presented in this document following an update of the generic site source term in relation to the relevant LLWR WAC and have determined that in general they remain within the acceptance criteria, [Ref-52]. Exceptions are the bead resins arising from the CD and LCW demineralisers. These resins have been identified as cross-boundary LLW/ILW wastes and are discussed in more detail in section 10.4.6. The management and disposal of the bead resins will follow the guidance set out in [Ref-34], ensuring timely communication with the disposal supplier, demonstration of BAT, effective use of the waste enquiry process and accurate identification in the UK Radioactive Waste Inventory. This approach will enable the resins to be disposed of at the LLWR following their on-site decay storage period.

13.2 Hitachi-GE Plan for the RWM Disposability Assessment

Hitachi-GE is currently undergoing a Generic Design Assessment to enable its Advanced Boiling Water Reactor to be built and operated in the UK. Part of this process requires a demonstration of disposability of the wastes generated through the construction, operation and decommissioning of the reactor through the Disposability Assessment process.

Hitachi-GE is required to obtain a view from RWM as to whether the HAW can be disposed of in line with plans for a future GDF in the UK. As part of obtaining that view, Hitachi-GE has provided RWM with a suite of information in support of the Disposability Assessment Submission for ILW and SF to allow them to undertake their assessments.

The information provided to RWM includes the following:

- Details of the characteristics of the waste and any proposed conditioning process, (e.g. drying, cementation, size reduction etc.). These details are supported by relevant references from Hitachi-GE, which include the physical, chemical and radionuclide properties envisaged for the wastes together with quantities envisaged to arise during operation and from future decommissioning activities.
- Specific parameters of the SF and any associated packaging which will be relevant to its condition at the time of disposal are addressed. The relevant parameters required to inform the disposability assessment are also included.
- A number of packaging and interim storage options are described using a number of standard containers, as currently used in the UK and known to RWM. The means whereby each of the wastes and SF may be rendered into a passively safe form, within a disposable package, are outlined in concept, based upon current UK practice and experience of similar wastes and SF arising on other UK sites.

- The ABWR ILWs are compared to other UK ILWs, which have already been assessed and found to be disposable by issue of final stage (LoC) to support the case that the envisaged waste packages will be disposable.

In order to ensure that the information required by RWM is as complete as possible and made available in a timely manner to enable a full assessment to be completed, regular meetings during the provision of the submission information and subsequent assessment period have taken place.

A response to the RWM assessment report is presented in [Ref-53]. The response summarises the findings of the RWM assessment of the disposability of wastes and SF generated for an operating UK ABWR which has been published in draft to Hitachi-GE [Ref-54] [Ref-55]. It also considers the impact of source term changes in the ILW and LLW wastes generated.

RWM concluded that sufficient information had been provided to produce valid and justifiable conclusions under the GDA Disposability Assessment process. Both spent fuel and ILW from the operation and decommissioning from a UK ABWR should be compatible with plans for transport and subsequent disposal and the assessment process has not identified any significant issues that challenge fundamental disposability. A total of 27 potential issues / opportunities have been identified by RWM. A review of these suggests that all are best addressed at the site specific assessment stage as they are related to maturing packaging plans rather than fundamental issues with disposability. It is noted in the RWM assessment report that '…numerous requirements and/or opportunities for further development were identified…is entirely consistent with expectations at this stage, due to the preliminary nature of the proposals…and the relatively high-level assessments performed.'

At the GDA stage of a reactor design's development, the submission to the RWM is relatively outline in nature. RWM apply a set of assumptions based on relevant operational experience from suitably similar waste generation sites, such as from Sizewell B, to create a more detailed data set for assessment. The future operator will continue the dialogue with RWM, providing more detailed proposals through the established LoC process.

14. Forward Action Plan

This strategy has been developed for GDA and hence is applicable at a 'generic site'. The main related items for action at site-specific stage are given in Table 14-1.

Table 14-1: Forward Action Plan

No.	Section Reference	Action	Delivery phase
1.	10.4.2	Selection and Implementation of site-specific Lower Activity Waste (LAW) (includes Very Low Level Waste (VLLW) and Low Level Waste (LLW)) management and disposal routes which take account of all prevailing drivers, including: • Application of the Waste Hierarchy • Application of BAT • Prevailing Regulatory regime • Business case and logistics	Future Operator

No.	Section Reference	Action	Delivery phase
		• Facilities and disposal routes, taking account of available technological developments	
2.	10.4.4	Provide site-specific submissions for and seek endorsement of Higher Activity Waste (HAW) packaging plans by issue of Letter of Compliance (LoC) from Radioactive Waste Management Ltd. (RWM) or its successor.	Future operator
3.	10.4.6	Monitor future developments in the management of borderline wastes, possibly through relevant user groups for the LLWR and GDF, to ensure that optimal treatment and waste routes are chosen and applied, particularly with respect to the CD and LCW demineraliser resins.	Future operator
4.	Appendix A, 0	Development of waste inventory and definition of waste treatment methodologies.	Hitachi-GE and future operator.

15. Conclusions

This RWMA document sets out management arrangements for the treatment, re-use and discharge of liquid and gaseous radioactive waste as well as the processing, interim storage and, where facilities are available, the disposal of radioactive wastes and SF generated by the UK ABWR in accordance with the UK Government policy and regulatory constraints. The requirements of the Environment Agency P&ID [Ref-1]document have been fulfilled as has consideration of the relevant REPS [Ref-2]. The management arrangements, design and supporting infrastructure of the UK ABWR provides a high degree of confidence that the management of liquid, gaseous and solid radioactive waste and SF are fully understood and that solutions are available within the envelope of current UK and international experience. Specifically it demonstrates that:

- The radioactive wastes generated by the UK ABWR are similar to those wastes generated by operating ABWRs and all waste streams have process routes to interim storage or final disposal solutions;
- The liquid and gaseous radioactive waste management systems are based on nationally or internationally proven technologies and ABWR experience and are available for the UK ABWR;
- A number of solid radioactive waste and SF management options which are based on nationally or internationally proven technologies and the experience from ABWR projects are available for the UK ABWR;
- Preferred, base case waste management solutions have been identified and chosen following the BAT process for a generic UK ABWR design.

This RWMA document may be used to support the production of an IWS and RWMC within the GDA process as well as to provide a foundation for the production of site specific IWS and RWMC documents by a future UK ABWR site operator.

Appendix A: Waste Stream and Spent Fuel Descriptions

1. Introduction

This Appendix provides currently available details of the wastes and SF which it is envisaged will be generated during the operational life of the UK ABWR and the details of the assumed decommissioning wastes which will arise at the end of life.

It should be recognised that all waste quantities and specific activities presented in this appendix are Source Term estimates based on operational experience, assumptions and calculation. The actual quantities and activities will be dependent on the future operational regime and history of the reactor site and, as such, the values quoted are subject to a degree of uncertainty. Unless specifically identified as cross-boundary waste, the uncertainties associated with specific activity and normal operations are not expected to alter the waste classification.

2. Nature and Quantity of the Wastes and Spent Fuel

A summary of the solid waste estimates arising from operation and decommissioning of the UK ABWR are given in [Ref-56]. Radioactivity inventory values are presented in the End User Source Term document [Ref-57].

The radionuclides included in the End User Source Term were chosen based upon a set of criteria including:

- Significant radionuclides for the radioactive waste system design taking account of:
  - LWMS and the radionuclides required for discharge assessment as well as the assessment of worker dose during routine operations
  - SWMS and the radionuclides that will dominate worker dose exposure
- Significant radionuclides for radioactive waste disposability, specifically:
  - Radionuclides with half-lives greater than 3 months
  - Those contributing beta-gamma and alpha radionuclides at greater than 90% radioactivity
  - Nuclides assessed as part of the existing repository for light water reactors in Japan
- Significant radionuclides for waste package transportation
- Significant radionuclides for the radioactive waste storage facility design

A total of 48 radionuclides have been identified as important for the Radioactive Waste End User Source Term.

The following tables summarise the information for each category of waste envisaged to arise from the UK ABWR during its operational life and from decommissioning activities. The tables present the total specific radioactivity based upon the dominant radionuclides in the waste, typically those that contribute >90% of the radioactivity. The waste classification and disposability have, however, been assessed on the suite of 48 radionuclides presented in the Radioactive Waste End User Source Term document [Ref-57]. Information is also included for the SF arising during the operational period.

The wastes are categorised as concentrated liquid waste (from an evaporator), waste sludge (crud) from filters, spent resins from the demineralisers and miscellaneous solid wastes which are activated or contaminated.

Liquids and gases which are discharged after abatement are not included in this Appendix. Wastes which

can be treated and disposed of to current licensed disposal facilities (e.g. the LLWR or licensed landfill site) are included. Wastes and SF which will be consigned to the GDF, when it is available, are included.

Consideration of uncertainty

It should be noted that the figures presented are a best estimate of radioactive wastes to be generated through the operation and decommissioning of a UK ABWR, however they will be subject to uncertainty. In particular, the decommissioning waste radioactivities will depend upon the operational regime of the reactor. During the operational phase monitoring, calculation and records, alongside international operational experience will be used to inform and minimise waste volume and radioactivity inventory uncertainty.

Whilst the UK ABWR is designed to minimise contamination BAT through all phases of the plant lifetime, the degree of contamination that will be present at the time of decommissioning is not known. As such, there will be inherent uncertainties in the radioactivities and waste quantities calculated in the decommissioning radioactive waste inventory. It is difficult to quantify these uncertainties at the GDA submission stage. The Decommissioning Waste Management topic report [Ref-17] provides a consideration of "Best Estimate" (BE) and "Design Basis" (DB) as calculated from the source term values to propose uncertainty factors.

This Radioactive Waste Management Arrangements document presents the BE values for operations and decommissioning waste, however, the impact of the decommissioning uncertainties is discussed in the Borderline Waste section 10.4.6.3 with reference to the waste types affected.

2.1 Operational VLLW

This category has been estimated based upon Japanese BWR and ABWR operational experience. The VLLW wastes will be of varied composition and source. All items arising will be managed according to the Waste Hierarchy and it is currently assumed that the services offered by LLWR Ltd. will be employed to optimise the management of the wastes and any disposals necessary.

Table A2.1-1: Details of VLLW Miscellaneous Solid Items

Parameter	Description
Waste Origin	Arising from operations and maintenance
Waste physical/chemical description	Low activity piping, motors and heat insulators from maintenance activities
Key parameters for conditioning	Solid items
Nature of radioactive material	Low levels of contamination
Main radionuclides/radioactivity	Various depending on source. Typically Fe-55, Co-60, H-3
Annual operational arising	13.8 m^3/year combustible 3.4 m^3/year non-combustible
Total operational arising	1032 m^3
Hazardous substances	Potential for low volume oil

2.2 Operational LLW

Note that the LLW limit is 12 GBq/t (1.20E+04 Bq/g) for beta/gamma and 4 GBq/t (4.00E+03 Bq/g) alpha activities and that the following activities are for un-processed/packaged wastes.

Depending upon the packaging technique used, the stated specific activities for wastes (to consign for disposal) may decrease; for example where the best technique for packaging is to mix with a cement formulation. Where a technique is chosen which may concentrate the waste (and hence the total radioactivity may move into the ILW range) this factor will be taken into account when choosing the best waste treatment technique.

Table A2.2-1: Details of LLW HEPA Filters

Parameter	Description
Waste Origin	Arising from filter changing in air treatment facilities: • Reactor Building exhaust • Turbine Building exhaust • Turbine Building high radiation exhaust • Radwaste Building exhaust • Service Building exhaust
Waste physical/chemical description	HEPA filters – 18 kg/filter
Key parameters for conditioning	Solid items comprising filter media and support frames
Nature of radioactive material	Low levels of contamination
Main radionuclides/radioactivity (Bq/g)	HVAC Filter (R/B) – Fe-55, Co-60, Mn-54, Zn-65; 2.1E+02 HVAC Filter (T/B) – Fe-55, Co-60, Mn-54; 2.2E-01 HVAC Filter (Rw/B) – Fe-55, Co-60, Zn-65, Mn-54; 2.3E+01
Annual operational arising	HEPA filters – 3.3 t/year
Total operational arising	HEPA filters – 198 t
Hazardous substances	None

Table A2.2-2: Details of LLW Bead Resins

Parameter	Description
Waste Origin	Arising from the CD, the LCW and HCW demineraliser Systems. The CD removes radionuclides from the main reactor coolant water after is has passed through the condenser. The origin of the LCW is as described above. The HCW comprises wastes with a higher particulate content and clean-up systems may include filtration, evaporators and demineralisers. Bead resins are used in the demineralisers to extract soluble radionuclides prior to reuse or discharge of the treated waste water.
Waste physical/chemical description	LCW & HCW Demineraliser; Cation Exchange Bead Resin, Anion Exchange Bead Resin. These resins have a cross linked polystyrene matrix. CD; Cation Exchange Bead Resin, Anion Exchange Bead Resin. These resins have a Styrene divinylbenzene copolymer matrix.
Key parameters for conditioning	In aqueous slurry form. Possible candidate for cementation, drying, incineration, compaction.
Nature of radioactive material	Soluble species arising from the noted systems; including soluble activated corrosion products and fission products
Main radionuclides/radioactivity* (Bq/g dry material)	CD – Co-60, Fe-55, Ce-144; 4.3E+04 LCW demineraliser – Co-60, Fe-55, Zn-65, Mn-54, Co-58; 2.1E+05 HCW demineraliser – Co-60, Ce-144, Fe-55; 6.3E+00 Average (weighted) – 6.6E+04
Annual operational arising	11.7 m^3/year
Total operational arising	699 m^3/60 years
Hazardous substances	None

*The CD and LCW demineraliser resins are identified as cross-boundary LLW/ILW wastes requiring decay storage and are discussed in section 10.4.6. The average specific activity of dry material is 6.6E+04 Bq/g beta/gamma (ILW). However, the resin is wet settled material at arising and the BAT treatment process of solidification in cement produces a final wasteform that is <1.20E+4 Bq/g (LLW).

Table A2.2-3: Details of LLW Concentrated Waste

Parameter	Description
Waste Origin	Arising from the HCW evaporator and stored in the CONW tanks for a period of decay before processing.
Waste physical/chemical description	Concentrates from various sources containing organic and inorganic particulate and soluble species.
Key parameters for conditioning	In aqueous slurry form. Possible candidate for cementation, drying, compaction.
Nature of radioactive material	Particulate and soluble species arising from the noted systems.
Main radionuclides/radioactivity (Bq/g)	H-3, Fe-55, Co-60; 7.6E+01
Annual operational arising	1.0 m^3/year
Total operational arising	60 m^3/60 years
Hazardous substances	None

Table A2.2-4: Details of LLW Miscellaneous Combustible Waste

Parameter	Description
Waste Origin	Dry active waste generated through routine and maintenance operations. The waste consists of LD pre-filter, polythene (sheet and bag), paper, wood, cloth (wipes and gloves), rubber gloves, spent active carbon.
Waste physical/chemical description	Heterogeneous non-metallic solid dry wastes, apart from the oil waste
Key parameters for conditioning	All wastes could be incinerated if within incinerator WAC. A significant proportion could be compactible.
Nature of radioactive material	Particulate contamination.
Main radionuclides/radioactivity	Powder Active Carbon: Fe-55, Co-60, Mn-54; 2.9E+02 Bead Activated carbon: Fe-55, Co-60, Mn-54; 1.1E+02 LD pre-filter material: Fe-55, Co-60, Mn-54; 1.0E+03
Annual operational arising	Spent active carbon; 10.6t/year Miscellaneous; 30.6 m^3 (depends on maintenance)
Total operational arising	Active carbon; 636t/60 years

Parameter	Description
	Miscellaneous; 1,836m^3
Hazardous substances	None

Table A2.2-5: Details of LLW Miscellaneous Non-Combustible Waste

Parameter	Description
Waste Origin	Arises during maintenance operations within the nuclear island. The waste mainly consists of contaminated RCA plant. Comprising metal plate, pipes, cables, lagging material, gas filters, concrete and glass. Also includes CF and LCW hollow fibre filter membrane.
Waste physical/chemical description	Metallic and other solids
Key parameters for conditioning	Dry largely non-compactible
Nature of radioactive material	Particulate contamination
Main radionuclides/radioactivity (Bq/g)	Fe-55, Co-60, Mn-54; 4.1E+03
Annual operational arising	Depend on maintenance and replacement
Total operational arising	Miscellaneous; 462m^3 CF & LCW spent hollow fibre media; 136 m^3
Potential hazardous substances (LLWR WAC [Ref-23])	Condition L2.17: Steel, plastic, electrical equipment Condition L2.18: Man-made mineral fibres (insulation)

2.3 Operational VLLW and LLW Summary

A summary of operational VLLW and LLW is presented in Table A0-1 below. The table provides an estimate of waste volumes and waste package numbers anticipated to be consigned annually to the identified waste routes. These estimates provide a clearer reference point of operational waste arising and outputs for consideration in GDA, as well as initial base working data for a future operator's environmental permitting submissions.

Primary waste quantity input data is as presented in Appendix sections 2.1 and 2.2 above. To achieve a more complete estimate of waste quantities than is available in the data of the aforementioned sections, reference assumptions, factors and calculations have been taken from the waste inventory calculations used in conceptual design studies of LLW processing systems. These include:

- The quantity and proportional segregation of VLLW. The proportion and quantity of VLLW metals has not been estimated, however any metal waste suitable for recycling will be segregated at source;
- The proportional segregation of LLW non-combustible waste into metal and non-metal streams;
- Average bulk densities to enable conversion between mass and volume;
- Compaction factors, where applicable, for soft, combustible wastes;
- Volume increase due to resin swelling after caustic soak treatment prior to cementation;
- Waste loading and consequent volume increase in the cement solidification process for wet-solid LLW;
- Average loading and type of waste containers;
- Average number of waste packages loaded into transport containers.

The content of Table A0-1 must be considered indicative due to the uncertainties inherent in the assumptions and estimated factors listed above. It will be subject to future change according to the evolution of the base data (waste quantities, source term etc.) and the development and definition of the waste treatment techniques, to be progressed by Hitachi-GE and a future site operator.

Table A0-1: Operational VLLW and LLW Summary

Category	Kind of Waste	Source	Rate of Arising per Unit		Treatment & Disposal	Waste Volume to be Disposed of (m^3/yr)	Treated Waste Volume for disposal (m^3/ yr)	Waste Package	Total No. of Packages per Unit per year		Disposal route
			m^3/yr	kg/yr					Waste Package	Transport Container	
VLLW	Miscellaneous combustible	Paper, polythene, cloth…	14	980	Compact and incinerate	3.0	3.0	Berglof Boxes	5	0.5 x HHISO	Incineration service
	Miscellaneous non-combustible	Metal, cable, lagging, gas filters, concrete and glass	3.4	5200	Metal recycling Direct disposal	3.4	3.4	TC19 210 litre Drums	17	0.5 x HHISO	Metal recycling service & LLWR
Dry-solid LLW	HVAC Filters	HEPA Filter	24	3300	Compact and incinerate	9.0	21	Berglof Boxes	25	5 x HHISO	Incineration service
	Miscellaneous combustible	Paper, polythene, cloth…	31	2200		6.0					
		Bead Activated Carbon	6.2	10000	Incinerate	6.0		TC19 210 litre Drums	32		
	Miscellaneous non-combustible	Metal	2.3	2900	Metal recycling	2.3	2.3	TC19 210 litre Drums	12	0.5 x HHISO	Metal recycling service
		Lagging, concrete and glass	5.4	8300	Direct disposal	5.4	5.4	TC19 210 litre Drums	27	1.5 x HHISO	LLWR
		CF & LCW Spent hollow fibre media	2.3	1100		2.3	2.3	TC01 HHISO	0.5		
Wet-solid LLW	Organic bead resin*	Condensate Demineraliser	9.6	11000	Cement encapsulation and direct disposal	12	41	TC03 THISO	5	5 x HHISO	
		LCW Demineraliser	1.8	2100							
		HCW Demineraliser	0.3	350							
	Sludge*	HCW Evaporator sludge	1.0	1200		1.0					
	Activated carbon	Granular Activated Carbon	0.6	600		0.6	1.9	210 litre Drums	10	0.5 x HHISO	

* If all organic bead resin is assumed as cross-boundary LLW/ILW and solidified in 210 litre drums with HCW evaporator sludge providing process water, the waste package numbers would be:

Averaged equivalent annual number of drums for decay storage: 198 drums

Average equivalent annual number of disposal packages: 7.5 HHISO.

2.4 Operational ILW

The following streams are those whose activities are envisaged to be greater than the LLW radioactivity limits of 12GBq/t (1.20E+04 Bq/g) for beta/gamma and 4GBq/t (4.00E+03 Bq/g) alpha and which are within ILW heat generation limits at disposal.

The stated activities are for the raw unprocessed wastes and the specific activities will change depending upon the packaging technique used and may also be influenced by radioactive decay of some radionuclides, in particular those which have a short half-life. For GDA it will be assumed that the categories will remain the same for conditioned and unconditioned wastes. However, if during site operations some ILW streams are re-categorised to LLW, the application of relevant LLW management techniques will ensure that the streams are adequately dealt with. No issues are envisaged with being able to treat any ILW stream as LLW, subject to the noted radioactivity limits.

Table A2.4-1: Details of ILW Filter Sludge (Crud)

Parameter	Description
Waste Origin	Arising from backwashing of CF and LCW filters. LCW arises from the drain sumps of the various components in the R/B, the drywell, the T/B and the Rw/B. It may also be collected in low chemical impurity waste collecting pools.
Waste physical/chemical description	Corrosion product Fe_2O_3, Fe_3O_4, FeOOH
Key parameters for conditioning	In aqueous slurry form. Possible candidate for cementation, drying, compaction.
Nature of radioactive material	Corrosion product particulate slurry and some dissolved species
Main radionuclides/radioactivity (Bq/g)	CF – Fe-55, Co-60, Mn-54; 6.1E+05 LCW filters - Fe-55, Co-60, Mn-54; 7.8E+06
Annual operational arising	CF – 1.2 m^3/year LCW – 0.3 m^3/year
Total operational arising	90 m^3/60 years
Hazardous substances	None

Table A2.4-2: Details of ILW Powder Resin

Parameter	Description
Waste Origin	Arising from the CUW and FPC filter demineralisers.
Waste physical/chemical description	Cation and Anion exchange powder resin. These resins have a cross linked polystyrene matrix. This stream also includes any particulate sludge which is filtered from the CUW and FPC systems
Key parameters for conditioning	In aqueous slurry form. Possible candidate for cementation, drying, incineration, compaction.
Nature of radioactive material	Soluble species arising from the noted systems; including particulate and soluble activated corrosion products and fission products
Main radionuclides/radioactivity (Bq/g)	CUW filter demineraliser – Fe-55, Co-60, Mn-54; 1.3E+08 FPC filter demineraliser – Fe-55, Zn-65, Co-60, Mn-54; 1.7E+07
Annual operational arising	CUW – 3.1 m^3/year FPC – 1.3m^3/year
Total operational arising	270 m^3/60 years
Hazardous substances	None

Table A2.4-3: Details of ILW Higher Activity Metals – Control Rods

It is estimated that the metal waste will be HLW at arising, decaying to ILW before the disposal route to the GDF is available (most recent estimate is 2100 [Ref-11]). Since the waste will be classed as ILW at disposal, it is included here.

Parameter	Description
Waste Origin	Cruciform shape and inserted between each group of 4 fuel assemblies external to the fuel channels and hence within non-boiling water. Performs the dual functions of power distribution shaping and reactivity control.
Waste physical/chemical description	Metallic construction containing stainless steel tubes in each wing of the cruciform filled with boron carbide powder or Hafnium.
Key parameters for conditioning	Dry, metallic, non-combustible.

Parameter	Description
Nature of radioactive material	Activation products.
Main radionuclides/radioactivity (Bq/g)	Co-60, Ni-63; Hafnium type – 2.1E+09 Boron carbide type – 7.3E+08
Annual operational arising	Hafnium type - 5 units; (0.5 t)/year Boron carbide type – 176 units (15.9 t)/30 or 40 years
Total operational arising	Hafnium type – 324 units (29.2 t) / 60 years Boron carbide type – 352 units (31.7 t) / 60 years Total – 676 units (60.9 t ; approx.203 m^3)/60 years
Hazardous substances	None.

Table A2.4-4: Details of ILW Higher Activity Metals – Fuel Channels

Parameter	Description
Waste Origin	Channels which contain each fuel bundle within the reactor core to direct the coolant flow and contain the boiling regions.
Waste physical/chemical description	Zircaloy box which surrounds the fuel bundle. Approx. 4.3 m long and 15 × 15 cm square.
Key parameters for conditioning	Dry, metallic, non-combustible.
Nature of radioactive material	Activation products.
Main radionuclides/radioactivity (Bq/g)	Co-60, Ni-63; 1.3E+08
Annual operational arising	6.8 t (approx. 34m^3)/year
Total operational arising	408 t
Hazardous substances	None

Table A2.4-5: Details of ILW Higher Activity Metals – Reactor Components, etc.

It is estimated that the metal waste will be HLW at arising, decaying to ILW before the disposal route to the GDF is available (most recent estimate is 2100 [Ref-11]). Since the waste will be classed as ILW at disposal, it is included here.

Parameter	Description
Waste Origin	Various reactor core components.
Waste physical/chemical description	Start-up Range Neutron Monitoring system (SRNM including dry tubes), Local Power Range Monitoring System (LPRM), Traversing In-core Probes (TIP) and, neutron source units.
Key parameters for conditioning	Dry, metallic, non-combustible.
Nature of radioactive material	Activation products.
Main radionuclides/radioactivity (Bq/g)	LPRM – Co-60, Ni-63; 1.3E+09 SRNM – Co-60, Ni-63; 3.0E+09 TIP – Co-60, Ni-63; 7.2E+06 Neutron source unit : · Neutron source – Ni-63, Cf-252; 5.1E+08 · Holder – Co-60, Ni-63; 3.7E+08
Annual/periodic operational arising	LPRM – approx. 1.8 t (LPRM: 0.5 t; Basket: 1.3 t) SRNM – approx. 0.9 t/10years (SRNM: 0.3 t; Basket: 0.6 t) TIP – approx. 0.3 t/10-20 years (TIP: 0.05 t, Basket: 0.25 t) Neutron source unit – 0.3 t/life (Unit: 0.05 t, Basket: 0.25 t)
Total operational arising	33 t/60 years (excluding basket weight)
Hazardous substances	None

2.5 Decommissioning Non-Radioactive Waste

The following waste details have been included for completeness. However, as they are not radioactive wastes they will not be addressed in detail in this document as part of GDA.

Table A0-1: Details of Non-Radioactive Decommissioning Wastes (Metal and Concrete)

Parameter	Description
Waste Origin	Non-radioactive metal and concrete from facility dismantling and demolition.
Waste physical/chemical description	Metal and concrete etc.
Key parameters for conditioning	Large items needing size reduction for disposal.
Metal Concrete Total arising	17,600 t 615,580 t 633,180 t
Hazardous substances	Lead, potentially from radiation protection

2.6 Decommissioning VLLW

The following information is approximate at this stage. However, it provides indicative quantities of wastes envisaged to arise in this category.

Table A2.6-1: Details of VLLW Decommissioning Wastes (Metal and Concrete)

Parameter	Description
Waste Origin	Contaminated and irradiated metal and concrete arising from various sources during decommissioning operations such as dismantling and decontamination.
Waste physical/chemical description	Metal and concrete
Key parameters for conditioning	Lightly contaminated or irradiated metal or concrete items.
Nature of radioactive material	Largely contaminated with some activation of metallic items.
Main radionuclides/radioactivity (Bq/g)	Fe-55, Co-60, Eu-152; <3.9E+00
Metal Concrete Total arising	14,270 t 11,090 t 25,360 t
Hazardous substances	None

Table A2.6-2: Details of VLLW Decommissioning Secondary Wastes (Combustible Miscellaneous Solid)

Parameter	Description
Waste Origin	Activated carbon from OG delay bed
Waste physical/chemical description	Activated carbon
Key parameters for conditioning	Combustible material
Nature of radioactive material	Slightly contaminated
Main radionuclides/radioactivity (Bq/g)	Cs-137; <5.4E-04
Total arising	72 t
Hazardous substances	None

Table A2.6-3: Details of VLLW Decommissioning Secondary Wastes (Non-Combustible Miscellaneous Solid)

Parameter	Description
Waste Origin	Recombining catalyst from OG system
Waste physical/chemical description	Metallic catalyst, non-combustible material
Key parameters for conditioning	Size reduction (cutting) may be necessary
Nature of radioactive material	Slightly contaminated
Main radionuclides/radioactivity (Bq/g)	Low specific radioactivity; H-3, C-14
Total arising	1 t
Hazardous substances	None

2.7 Decommissioning LLW

The following information is approximate at this stage. However, it provides indicative quantities of wastes envisaged to arise in this category.

Table A2.7-1: Details of LLW Decommissioning Waste (Metal and Concrete)

Parameter	Description
Waste Origin	Contaminated and irradiated metal and concrete. Arising from various sources during decommissioning
Waste physical/chemical description	Metallic and concrete. Pool furniture, including spent fuel racks.
Key parameters for conditioning	Large items needing size reduction for disposal to Low Level Waste Repository.
Nature of radioactive material	Activation products, contaminated products
Main radionuclides/radioactivity (Bq/g)	Fe-55, Co-60, Eu-152; <1.1E+04
Metal Concrete Total arising	7,790 t 1,320 t 9,110 t
Potential hazardous substances (LLWR WAC [Ref-23])	Condition L2.17: Steel and metal alloys. Condition L2.18: Man-made mineral fibres (insulation)

Table A2.7-2: Details of LLW Decommissioning Secondary Wastes (Combustible Miscellaneous Solid)

Parameter	Description
Waste Origin	• Combustible materials generated in the demolition of metal and concrete • Spent activated carbon generated in the treatment of washing liquid waste (LD) • HVAC and other filters
Waste physical/chemical description	Heterogeneous non-metallic solid dry waste
Key parameters for conditioning	All wastes could be incinerated if within incinerator WAC. A significant proportion could be compactible.
Nature of radioactive material	Activation and / or contaminated products

Parameter	Description
Main radionuclides/radioactivity (Bq/g)	Fe-55, Co-60, Eu-152; <2.9E+02
LD activated carbon Miscellaneous combustible materials Total arising	340 t (wet settled material) 669 t 1009 t
Hazardous substances	None

Table A2.7-3: Details of LLW Decommissioning Secondary Wastes (Non-combustible Miscellaneous Solid)

Parameter	Description
Waste Origin	• Non-combustible materials generated in the demolition of metal and concrete • Concrete sludge generated in the demolition of concrete • Filters from underwater metal cutting • Spent demineraliser resin generated in the treatment of plant retained water • Spent filter from LD system • Abrasive blasting materials and removed particles generated in decontamination • LCW hollow fibre filter membrane in LCW filter in water treatment:
Waste physical/chemical description	Metal, concrete, filter, resin, abrasive blasting material
Key parameters for conditioning	Dry largely non-compactible. The resin may be immobilised in cement.
Nature of radioactive material	Activation products, contaminated products
Main radionuclides/radioactivity (Bq/g)*	Water treatment resins - Fe-55, Co-60, Eu-152; 5.4E+04(*) Others - Fe-55, Co-60, Eu-152; <4.4E+03
Total arising	Spent resin: 62 m^3 LCW hollow fibre filter membrane: 0.6 m^3 Concrete sludge: 10m^3 Miscellaneous solid: 1,804 t
Potential hazardous substances (LLWR WAC [Ref-23])	Condition L2.17: Steel, plastic, electrical equipment

*: The plant retained water characteristics at decommissioning are subject to significant uncertainty at GDA and the specific radioactivity of 5.4E+04 Bq/g wet settled material at arising is an upper estimate. The water treatment resins are similar to the bead resins presented in Table A2.2-2 that are identified as cross-boundary ILW/LLW wastes. At decommissioning, any water treatment resins that cannot be disposed of as LLW due to their radioactivity will be processed as ILW, as proposed for the spent resins identified in Table A2.8-2.

Table A2.7-4: Details of Decommissioning Liquid Waste

Parameter	Description
Waste Origin[1]	• Plant retained water (reactor, pool, etc.) • System decontamination liquid waste • Laundry / personnel washing facilities
Waste physical/chemical description	Contaminated liquid waste.
Key parameters for discharge[1]	Chemical condition and radiation level.
Nature of radioactive material	Contaminated liquid waste.
Main radionuclides/radioactivity (Bq/g)	H-3, Fe-55, Co-60; <2.7E+02. Radioactivity content will be managed to within permitted decommissioning discharge limits.
Total arising for discharge during 20 years after permanent shutdown	221,710 m^3
Hazardous substances	None

[1] Waste water will be treated and reused as far as practicable before final discharge. The exception is the laundry and washing facility waste water which will be treated and discharged as normal.

Table A2.7-5: Details of Decommissioning Gaseous Waste

Parameter	Description
Waste Origin	Radioactive gaseous waste generated from various sources during decommissioning: • Evaporative losses from pools • Gases and particulate produced during cutting work
Waste physical/chemical description	Gaseous discharge
Key parameters for discharge	Chemical condition and radiation level
Nature of radioactive material at discharge	H-3, C-14 and others in air

Parameter	Description
Main radionuclides/radioactivity (Bq)	H-3, C-14; <5.0E+12 (total activity discharge during the decommissioning period) Discharges will be managed to within the permitted decommissioning discharge limits.
Total arising	-
Hazardous substances	None

2.8 Decommissioning ILW

The following information is approximate at this stage. However, it provides indicative quantities of wastes envisaged to arise in this category. It is estimated that approximately 70t of RIN metal waste will be HLW at arising, decaying to ILW before the disposal route to the GDF is available around 2130. Since the waste will be classed as ILW at disposal it is included here.

Table A2.8-1: Details of ILW Decommissioning Metal Wastes

Parameter	Description
Waste Origin	Reactor core components (RPV and RIN) and from areas subject to activation.
Waste physical/chemical description	Activated metal components
Key parameters for conditioning	Dry, metallic, non-combustible. Some large items needing size reduction for packaging and disposal.
Nature of radioactive material	Activation products
Main radionuclides/radioactivity (Bq/g)	Fe-55, Co-60; <1.1E+10
Total arising	810 t
Hazardous substances	None

Table A2.8-2: Details of ILW Decommissioning Secondary Wastes (Non-combustible Miscellaneous Solid)

Parameter	**Description**

Waste Origin	• Underwater filter generated in the dismantling and cutting of RIN
	• Spent resin generated in water treatment:
	  o System decontamination liquid
	  o CUW demineraliser (approximately 6 months operation following shutdown)
	  o FPC demineraliser (approximately 10 years operation following shutdown)
	• Filter sludge generated in water treatment

Waste physical/chemical description	Filter (dross etc.), Resin, Sludge
Key parameters for conditioning	Dry largely non-compactible.
Nature of radioactive material	Activation products, contaminated products
Main radionuclides/radioactivity (Bq/g) Resins are given as Bq/g dry material	Fe-55, Co-60; <5.3 E+08
Total operational arising	Spent resin: 84 m^3 Filter: 32 t Filter Sludge: 0.9t (3m^3)
Hazardous substances	None

2.9 Spent Fuel

The following table summarises the general information currently available on the SF. The document [Ref-58] indicates the detailed parameters which are required for GDA, and which will be needed in due course. The table below also summarises specific information which RWM have requested to support the Disposability Assessment (see 13.2).

Table A2.9-1: Details of SF Assemblies

Parameter	Description
Origin	Uranium dioxide fuel pellets within Zircaloy cladding form the fuel assemblies, which undergo fission and produce heat. A proportion of this heat is ultimately converted to electricity. The fission products and actinides produced during the fission process are considered as waste. In addition to the fission products and actinides, the structures of the fuel assemblies are activated and, at point of discharge from the reactor, contain activation products.
Physical/chemical description	The reactor core consists of fuel rods held in bundles by spacer grids and top and bottom fittings. The fuel rods consist of uranium dioxide pellets stacked in a cladding tube, plugged and seal welded. Fuel assembly design is GE14 type. Materials of construction are Zircaloy, stainless steel, Inconel, ceramic UO_2 and Gd_2O_3.
Specific information required by RWM	1. How the SF is believed to evolve during interim storage period. Initially this may be based upon current Japanese practice, but may need to be modified in the future if UK interim storage conditions are different. 2. SF data comprising a full radionuclide inventory of the fuel and any non-fuel core components. To include initial enrichment, burn up (and variability), any clad impurities, burnable poisons. 1 year cooled data would be helpful and provision of heat and A2 information if available. 3. Details of Uranium type and specifically if any reprocessed material was used as this can affect the U236 profile. 4. Variabilities in burn up, for example a max core burn up value may include variabilities for individual fuel assemblies as a result of fuel shuffling. 5. Operational strategy for the core to provide understanding of the burn up variations. 6. Information on the strategy to be adopted for failed fuel.

Parameter	**Description**
Key parameters for conditioning	Dry, metallic, non-combustible, heat generating. Approx. 4.5 m long.
Nature of radioactive material	Fission products, activation products and actinides.
Annual discharge from core	150 assemblies (approximately)
Total discharge from core	9,600 assemblies (approximately)
Hazardous substances	None

Appendix B: Sampling and Monitoring

Consideration of the sampling, measurement and monitoring of solid radioactive wastes from production to removal from site is presented in the document Radioactive Solid Wastes Monitoring Requirements [Ref-10]. The document does not consider SF.

The document reflects the UK ABWR and waste processing facilities concept design development and is an initial step to:

- Identifying sampling, monitoring and measurement requirements and guidance.
- Provide an overview of where monitoring, measurement and sampling activities fit into satisfying regulatory requirements.
- Identify relevant steps in the UK ABWR solid radioactive waste management and treatment process where monitoring, measurement and sampling is applied, and
- Propose techniques or methodologies to satisfy the monitoring, measurement and sampling requirements based on currently available and utilised techniques and equipment.

The Radioactive Solid Wastes Monitoring Requirements document aims to propose solutions that are consistent with BAT, taking due consideration of the maturity of design. The proposals given provide for characterisation as close to the point of waste generation as is practicable to ensure that:

- Onward characterisation requirements and scope are minimised;
- Segregation to simple and stable waste forms is maximised;
- Downstream facility safety cases are not compromised;
- Disposability of the final waste form is achieved;
- Dose uptake and spread of contamination is minimised (ALARA).

To demonstrate in GDA that the monitoring requirements are achievable, all identified or proposed techniques are based upon consideration of currently applied methodologies and are therefore well known. To keep dose uptake ALARA, the scope of characterisation requirements has been considered and minimised, and proposals for remote deployment and operation are made where appropriate.

Further development of the UK ABWR waste management system is required and recommended actions to ensure continued demonstration of BAT are noted, specifically:

- Consideration of the relevant sampling, measurement and monitoring methodologies and technologies developed (and in development) internationally.
- Consideration of those relevant and available methodologies and technologies with respect to installation, maintenance and operation within the UK ABWR detailed design and safety case for the following buildings:
    - R/B
    - Rw/B
    - T/B
    - S/B
    - Waste treatment facilities
    - ILW Interim Store.
- An assessment and comparison of relevant and available methodologies and technologies with respect to the detailed UK ABWR waste treatment facility process specifications.

The Radioactive Solid Wastes Monitoring Requirements document presents its proposals in the following format:

i. Identification and description of regulatory requirements and relevant guidance
ii. Identification and description of essential supporting information when considering characterisation:
    - Design and provenance,
    - Scaling factors / fingerprints,
    - Process and quality control.
iii. Characterisation requirements
iv. Clearance monitoring requirements
v. Transport measurement requirements
vi. Waste processing flow sheets from generation to removal from site that identify monitoring requirements for:
    - Dry solid LLW
    - Wet solid LLW
    - Wet solid ILW
    - Dry solid ILW
vii. Description of monitoring requirements and proposed solutions for the measurement steps identified in the flow sheets above
viii. Appendices presenting examples of currently available measurement and sampling instruments.