Generic design assessment

AP1000 nuclear power plant design by Westinghouse Electric Company LLC

Assessment report
Solid radioactive waste (LLW and ILW)

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Protective status	This document contains no sensitive nuclear information or commercially confidential information.
Process and information document[1]	The following sections of Table 1 in our process and information document are relevant to this assessment: 2.1 – a description of how radioactive wastes will arise, be managed and disposed of throughout the facility's lifecycle 2.4 – design basis estimates and substantiation of annual arisings of solid radioactive waste during operation and decommissioning 1.5 – an analysis should be provided that includes an evaluation of options considered and shows that the best available techniques will be used to minimise the production and discharge or disposal of waste
Radioactive substances regulation environmental principles[2]	The following principles are relevant to this assessment: RSMDP3 - Use of BAT to minimise waste RSMDP8 - Segregation of wastes RSMDP9 – Characterisation RSMDP10 – Storage RSMPD15 - Requirements and conditions for disposal of wastes
Report author	Saffron Price-Walter

1. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Environment Agency, Jan 2007.

   http://publications.environment-agency.gov.uk/pdf/GEHO0107BLTN-e-e.pdf

2. Regulatory Guidance Series, No RSR 1: Radioactive Substances Regulation - Environmental Principles (REPs), 2010.

   http://publications.environment-agency.gov.uk/pdf/GEHO0709BQSB-e-e.pdf

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1 Summary

1 This report presents the findings of our assessment of the AP1000's solid radioactive waste (low level waste (LLW) and intermediate level waste (ILW)) based on information submitted by Westinghouse in its environment report (ER) and supporting documents.

2 We conclude that:

a) In its submission, Westinghouse describes how LLW and ILW will be generated, managed and disposed of throughout the facility's lifecycle.

b) Westinghouse has identified all LLW and ILW waste streams that an AP1000 will typically produce.

c) Waste will be treated and conditioned using proven and recognised techniques. However, the Health and Safety Executive (HSE) will be looking at Westinghouse's plans for the conditioning of waste produced by an AP1000 in more detail as part of its Step 4 assessment, and our final decision will be informed by this work.

d) The design is not expected to produce LLW or ILW for which there is no foreseeable disposal route. However, the regulators need more information on the potential for degradation of ILW over the longer term that might affect its disposability and safe storage. Westinghouse provided information on 1 March 2010, which was considered in our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d). HSE is reviewing this information in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document.

e) Westinghouse has provided estimates for the annual arisings (during operations and decommissioning) of LLW and ILW. The arisings of LLW and ILW exceed the European Utility Requirement objective of less than 50 m^3 per 1000 MWe plant-year of operation (EUR, 2001), although, these arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009).

f) Westinghouse has provided basic evidence of how they will minimise the disposal of LLW and ILW.

3 However, our conclusion is subject to the following other issues:

a) Disposability of ILW following longer term interim storage pending disposal.

b) Provide evidence at site-specific permitting that the specific arrangements for minimising the disposals of LLW and ILW for each site represents best available techniques (BAT).

4 Our findings on the wider environmental impacts and waste management arrangements for the AP1000 reactor may be found in our consultation document (Environment Agency, 2010e).

2 Introduction

5 Guidance on our generic design assessment (GDA) process was published in January 2007 (process and information document (P&ID) (Environment Agency, 2007)). Table 1, section 2.1 of the P&ID requires the requesting parties (RPs) to provide a description on how radioactive waste will arise, be managed and disposed of throughout the facility's lifetime. Table 1, section 2.1 of the P&ID states that:

"A description of how radioactive wastes will arise, be managed and disposed of throughout the facility's lifecycle. This should include:

a) sources of radioactivity and matters which affect wastes arising;

b) gaseous, liquid and solid wastes;

c) discharge points for gaseous wastes and discharge routes for liquid wastes;

d) disposal routes for solid wastes (including any proposals for incineration of combustible waste)."

6 Table 1, section 2.4 of the P&ID requires the RPs to propose design basis estimates and substantiation of annual arisings of solid radioactive waste. Table 1, section 2.4 of the P&ID states that:

> "*Design basis estimates and substantiation of annual arisings of solid radioactive waste during operation and decommissioning. Wastes should be identified in terms of category (high level waste (HLW), ILW, LLW), physico-chemical characteristics and proposed disposal route (if any). Quantification should be in terms of activity of key individual radionuclides and overall groupings of radionuclides (e.g. total alpha), mass and volumes.*
>
> *The requesting party should obtain, and provide, a view from the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source in providing such advice) on the disposability of any proposed arisings of ILW or HLW*."

This P&ID requirement includes all radioactive wastes arisings, including those from operations and decommissioning, and includes waste arising from all activities, both routine and reasonably foreseeable non-routine activities (e.g. breakdown maintenance). This information is required:

a) in support of the waste and spent fuel strategy and BAT analysis which is the subject of P&ID requirements 1.4, 1.5 and 2.1;

b) in support of the assessment of the impact of any proposed direct disposal of waste (for example by on-site incineration);

c) to provide a basis for indicative limit setting where appropriate;

d) to provide confidence that wastes will not be generated for which there is no foreseeable disposal route.

7 Table 1, section 1.5 of the P&ID requires the RPs to provide an analysis that includes an evaluation of options considered and show that BAT will be used to minimise the production and discharge or disposal of waste. Table 1, section 1.5 of the P&ID states that:

> "*An analysis should be provided that includes an evaluation of options considered and shows that the best available techniques will be used to minimise the production and discharge or disposal of waste. This should include:*
>
> – *a description of the means used by each significant waste generating and management process to minimise waste arising and discharged or disposed of and a demonstration that these are the best practicable;*

- *a review of design features, including those of fuel usage, such as burn-up and rating, that facilitate minimisation of arisings and disposal of waste during operation of the reactor;*
- *a review of design features that facilitate decommissioning and minimise the arisings of decommissioning waste.*

Reference should be made to:

- *all periods of "operation", for example at power, shutdown, maintenance and refuelling (including related tasks such as fuel and flask handling);*
- *transitory periods (e.g. returning to power following shutdown);*
- *issues relating to minimising radioactivity source terms (for example materials of construction and coolant chemistry);*
- *abatement issues (for example optimising resin types and usage in treatment systems);*
- *process control and monitoring arrangements including fault detection;*
- *the selection of materials and physical features to minimise activation and contamination, facilitate decontamination, removal of components etc;*
- *practices at other existing and proposed facilities.*"

8 We are carrying out our assessment in two stages:

a) preliminary assessment – we examine the outline details of the requesting party's submission to find out if further information is needed, if there are any issues that are obviously unacceptable, or if there needs to be any significant design modifications;

b) detailed assessment – we examine the submission in detail to decide initially if we might issue a statement of design acceptability. We will only make our final decision after we have consulted the public and considered the responses we receive.

9 Westinghouse submitted its AP1000 design for GDA in August 2007. We published the findings of our preliminary assessment in March 2008 (Environment Agency, 2008).

10 We found that the submission did not contain the level of information we needed to carry out a detailed assessment but Westinghouse committed to providing further information. In fact it provided a completely revised submission, its environment report (ER) with supporting documents. They have published the ER and other documents on its website (https://www.ukap1000application.com/ap1000_documentation.aspx).

11 Our detailed assessment of the information contained in the revised submission on solid radioactive waste (low level waste (LLW) and intermediate level waste (ILW)) is documented within this assessment report. The assessment of disposability of ILW is the subject of a separate assessment report (Environment Agency, 2010d). The assessment of spent fuel and non-radioactive wastes are also documented within other assessment reports (Environment Agency, 2010b and Environment Agency, 2010c).

3 Assessment

3.1 Assessment Methodology and Process

12 The basis of our assessment was to:

a) review appropriate sections of the ER and its supporting documents;

b) hold technical meetings with Westinghouse to clarify our understanding of the information presented and explain any concerns we had with that information;

c) raise Regulatory Observations (ROs) and Technical Queries (TQs) where we believed information provided by Westinghouse was insufficient;

d) assess the techniques proposed by Westinghouse to prevent and minimise production of solid radioactive waste using our internal guidance and regulatory experience;

e) decide on any issues to carry forward from GDA.

13 In undertaking our assessment, we have worked closely with HSE. We have also had discussions with other regulators; the Radiation and Nuclear Safety Authority of Finland (STUK) and the United States Nuclear Regulatory Commission (NRC).

14 As detailed in our preliminary assessment report (Environment Agency, 2008), Westinghouse's submission received in August 2007 did not contain the level of information that was needed to carry out a detailed assessment on integrated waste strategy. Therefore, as a result a Regulatory Issue (RI) was raised in February 2008.

15 In January 2009, Westinghouse provided additional information; revision 1 of its ER with supporting documents. We assessed information contained in the ER but found that while much improved from the original submission it still lacked detail on some aspects of LLW and ILW arisings. Subsequently, two Regulatory Observations (ROs) were raised jointly by the Environment Agency and HSE; one requesting a standalone strategy for waste management and the other a disposability case for spent fuel and ILW.

16 Additionally, several TQs were also raised.

17 The following table provides information on the RI, ROs and TQs that were raised which are relevant to LLW and ILW:

RI/RO/TQ number and title	Reason for raising	Comments on response
RI-AP1000-0001 Information required by the Environment Agency for the detailed assessment stage	Limited information received in August 2007 submission.	Westinghouse provided a commitment (to which we assigned the unique number CM-AP1000-1) to provide information to comply with the P&ID requirements identified in the schedule to RI-AP1000-001 within several future submissions.
RO-AP1000-034 RO-AP100034.A01 RO-AP1000-034.A02 RO-AP1000-034.A03 RO-AP1000-34.A04: Integrated Waste Strategy	Limited information received in August 2007 submission and January 2009 information. Hence RO asked for a comprehensive integrated waste strategy and documentary evidence that BAT has been used.	Documentation provided.

RI/RO/TQ number and title	Reason for raising	Comments on response
RO-AP1000 -60 RO-AP1000-060.A01: Disposability of Spent Fuel and ILW	The regulators consider that Westinghouse should show how and when the matters identified in the radioactive waste management directorate disposability assessments will be addressed.	This response was considered in our Disposability Assessment Report (Environment Agency, 2010d).
TQ-AP1000-92: Disposability of AP1000 Wastes	This TQ asks for the documentation from Westinghouse's review of waste from AP1000 systems and rooms.	Documentation provided.
TQ-AP1000-91: AP1000 BAT Documentation	Limited information on BAT received in August 2007 submission and January 2009 information. Hence TQ asked for documentation from the 'optioneering workshop and BAT study'.	Documentation provided.
TQ-AP1000-139: AP1000 Spent Ion Exchange Resins	Secondary spent ion exchange resins at Sizewell B are currently disposed of as LLW. Hence TQ asks for justification that all the Westinghouse spent ion-exchange resins are ILW.	Justification that spent ion exchange resins are ILW provided, although the polishing (secondary) resin will be LLW.
TQ-AP1000-140: Disposability of AP1000 Low Level Waste	No information on how LLW meets the conditions for acceptance (CFA) for the disposal facility in August 2007 submission and January 2009 information. This TQ asks for evidence that the AP1000 LLW is acceptable at current disposal facilities.	No evidence provided that LLW meets CFA for the low level waste repository (LLWR). Hence, TQ-AP1000-256 raised.
TQ-AP1000-256: Disposability of AP1000 LLW at the LLWR	Since the response to TQ-AP1000-140 was unacceptable, this TQ asks for evidence that LLW meets the CFA of the LLWR.	Evidence provided that LLW meets the CFA of the LLWR.

RI/RO/TQ number and title	Reason for raising	Comments on response
TQ-AP1000-93: AP1000 LLW Proposed for Incineration	No information on how LLW proposed for incineration meets the CFA for available incinerators in August 2007 submission and January 2009 information. This TQ asks for evidence that the AP1000 LLW proposed for incineration is acceptable at current incinerators.	No evidence on how the fingerprint / chemical make-up of the waste proposed to be incinerated meets the CFA of currently available incinerators. Additionally, TQ response only mentions incineration of waste oils but it is stated in the response to TQ-AP1000-140 that condensate polishing resins will be incinerated. Hence TQ-AP1000-257 raised.
TQ-AP1000-257: Disposability of AP1000 LLW Oils and Condensate Polishing Resins	Since the response to TQ-AP1000-93 was unacceptable, this TQ asks for a copy of the relevant incinerator(s)'s CFA, and a commentary that demonstrates how the physical, chemical and radiological characteristics of both the waste oils and condensate polishing (CPS) resins are compatible with the incinerator(s)'s CFAs.	Evidence provided that the waste oils and CPS resins meets the CFA of an available incinerator.
TQ-AP1000-141: Solid Radioactive Waste Estimates	No evidence provided in August 2007 submission and January 2009 information on whether the solid radioactive waste estimates are realistic for the AP1000. This TQ asks for justification that the estimates are realistic.	Limited information provided. Hence, TQ-AP1000-383 raised. Additionally, the Environment Agency and HSE attended a presentation by Westinghouse in February 2010 on its processes for deriving data on radioactive wastes where further confidence was gained.
TQ-AP1000-167: Storage of AP1000 LLW	This TQ asks for further details (than that in the August 2007 submission and January 2009 information) on the short term buffer storage of LLW in the waste treatment building, e.g. the capacity of the store.	Information provided.

RI/RO/TQ number and title	Reason for raising	Comments on response
TQ-AP1000-142: AP1000 ILW Decay to LLW	No information in August 2007 submission and January 2009 information. Hence, this TQ asks for information on the management of ILW that may decay to LLW during storage.	Information provided.
TQ-AP1000-255: Category and Management Arrangements for AP1000 Waste	No information on some waste streams in the August 2007 submission and January 2009 information. Hence, this TQ asks for details on the management arrangements of the following waste streams; • high-dose-rate contaminated metals, plastics, cloth, etc., that arise from outage operations; • 'sludges' arising from the cleaning of the bottoms of liquid waste treatment tanks and various sumps; • 'evaporator concentrates' (expected to be rich in boron) that might arise from operations to minimise activity release in liquid effluent.	Basic information provided.
TQ-AP1000-381: Large, Solid Radioactive Waste Items	No information received in August 2007 submission and January 2009 information. Hence this TQ asks for demonstration that large one-off items, such as reactor pressure vessel heads and steam generators that could need replacing during operation can be stored, conditioned for disposal and are disposable.	Information only provided on steam generators as Westinghouse assumes that a reactor head is not expected to require replacement during the operational period. We had expected them to consider that a reactor head may fail and hence, TQ-AP1000-406 raised.
TQ-AP1000-406: Reactor Pressure Vessel Head	Since the response to TQ-AP1000-381 was unacceptable, this TQ asks for demonstration that if a reactor pressure vessel head were to fail during operation, it can be stored, conditioned for disposal and is disposable.	Basic information provided.

RI/RO/TQ number and title	Reason for raising	Comments on response
TQ-AP1000-383: Solid Radioactive Waste Data	Since the response to TQ-AP1000-141 was unacceptable, and to provide confidence that the estimates in the August 2007 submission and January 2009 information are realistic for the AP100, further information was requested by this TQ.	Information provided. Additionally, the Environment Agency and HSE attended a presentation by Westinghouse in February 2010 on its processes for deriving data on radioactive wastes where further confidence was gained.

18 A final version of the ER was received in April 2010 which is published along with other documents on the Westinghouse website (https://www.ukap1000application.com/ap1000_documentation.aspx). These documents incorporate the relevant information in the RO and TQ responses.

3.2 Assessment Objectives

19 We started our assessment with some key questions to answer:

a) Have all the sources of LLW and ILW been identified?

b) How will LLW and ILW be treated and conditioned?

c) Have all the disposal routes for LLW and ILW been identified?

d) Have the arisings of LLW and ILW been quantified?

e) Has BAT been applied to minimise the arisings of LLW and ILW?

3.3 Westinghouse Documentation

20 We referred to the following documents to produce this report:

Document reference	Title	Version number
UKP-GW-GL-790	UK AP1000 Environment Report	3
UKP-GW-GL-054	UK AP1000 Integrated Waste Strategy	0
UKP-GW-GL-026	AP1000 Nuclear Power Plant BAT Assessment	1
UKP-GW-GL-027	Radioactive Waste Arisings, Management and Disposal	1
UKP-GW-GL-012	GDA: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the Westinghouse Advanced Passive PWR (AP1000)	
NXA/10897959	GDA: Disposability Assessment for Wastes and Spent Fuel arising from Operation of the Westinghouse Advanced Passive PWR (AP1000) Part 1: Main Report	
LL/10900069	GDA: Disposability Assessment for Wastes and Spent Fuel arising from Operation of the Westinghouse Advanced Passive PWR (AP1000) Part 2: Data Sheets and Inventory Tables	
UKP-GW-GL-057	UKAP1000 NDA Data Sheet Submission	0
UKP-GW-GL-061	Acceptability of AP1000 Waste Oil for Incineration	0
UKP-GW-GL-055	UK AP1000 Radioactive Waste Management Case Evidence Report for Intermediate Level Waste	0
UKP-GW-GL-056	UK AP1000 Radioactive Waste Management Case Evidence Report for High Level Waste	0
UKP-GW-GL-004	Process Mass Balance for AP1000 Solid Waste	0
UKP-GW-GL-058	UK AP1000 D1 Submission	0
UKP-GW-GL-023	Waste Disposability Schedule for AP1000	0
UKP-GW-GL-039	Radwaste Treatment Options Study Report	0
UKP-GW-GL-003	Solid Waste Activity Calculation from AP1000	0
TQ-AP1000-383	Solid Radioactive Waste Data	07/01/10
REG WEC00098	GDA – Disposability Assessment for the Westinghouse Passive Pressurized Water Reactor (AP1000) – Westinghouse Electric Company Opinion	19/10/09

21 We use short references in this report, for example:

a) ER = Environment report;

b) IWS = AP1000 integrated waste strategy document.

3.4 Creation of Solid Waste

22 The sources of solid radioactive waste generated in the AP1000 are summarised in Table 3.5-1 in the ER and a detailed breakdown of the wastes can be found in Appendix A of the ER.

23 Westinghouse provides information in section 3.5.3.1 of the ER about LLW, which includes dry active wastes, general trash and mixed waste as a result of normal plant operation. Section 3.5.3.1 of the ER states that waste will generally contain: plastics, paper, metallic items, clothing, rubber, filters, redundant equipment, glass and wood.

24 In section 3.5.3.2 of the ER, Westinghouse states that ILW comprises mainly of spent ion exchange resins, activated carbon and used filters. It states that the production of these wastes is intermittent and associated with replacement and maintenance procedures.

25 The quantities of solid radioactive waste generated by the AP1000 are summarised in ER Table 3.5-1.

26 Westinghouse states in ER section 3.5.3 that the solid radioactive waste estimates in the ER are best, realistic estimates. A major source of information for its calculations was consultations with experienced personnel who have worked in the design of the AP1000 and worked on existing plants.

27 The estimated gross annual volumes of solid LLW produced during the operation and maintenance of the AP1000 is 163.98 m^3 and the estimated volume of treated LLW to be disposed of or stored per year is 61.14 m^3. Therefore, for the conditioned waste, assuming the AP1000 design is for a single, pressurised water reactor (PWR) capable of generating in total 1117 MW of electricity, the estimated volume is 54.7 m^3 per 1000 MWe plant-year of operation.

28 The estimated gross annual volumes of solid ILW produced during the operation of the AP1000 is 10.25 m^3 and the estimated volume of final solid ILW packages to be disposed of or stored per year is 40.86 m^3. Therefore, for the conditioned waste, assuming the AP1000 design is for a single, pressurised water reactor (PWR) capable of generating in total 1117 MW of electricity, the estimated volume is 36.6 m^3 per 1000 MWe plant-year of operation.

29 The IWS states that solid ILW decommissioning waste will be handled in a similar way to that used for operational and maintenance waste, but with a size reduction stage incorporated to allow larger waste items (for example, structural steel) to be processed into a form that allows immobilisation.

30 The quantities and classification of decommissioning waste associated with the AP1000 are shown in Appendix A3, Appendix A4 and Appendix A6, and summarised in Table 3.5-10 of the ER. An estimated volume of LLW from decommissioning is around 5500 - 6000 m^3. An estimated volume of ILW from decommissioning is 800 m^3. A typical schematic for treatment of decommissioning waste is shown in Figure 3.5-21 of the ER.

31 The estimates in Westinghouse's submission for the volumes of operational LLW and ILW appear to be reasonable for the AP1000. These estimates were derived by Westinghouse using information from consultations with experienced personnel who have worked in the design of the AP1000 and worked on existing plants. Additionally, Westinghouse has provided a comparison of its estimated solid radioactive waste arisings against available operating plant experience in its response to TQ AP1000-383. This supplementary information provides confidence that the estimates are realistic for the UK AP1000.

3.5 Management and Disposal of Low Level Waste

32 In this section we cover our assessment of the management and disposal of low level radioactive wastes (LLW). LLW is defined in the UK as 'solid radioactive waste having a radioactive content not exceeding 4 GBq per tonne (GBq te^{-1}) of alpha or 12 GBq te^{-1} of beta/gamma activity', but we also consider here some liquid waste such as contaminated oils. These types of low level waste are usually suitable for disposal at the low level waste repository (LLWR) near Drigg, disposal by on or off-site incineration, or transfer off-site for recovery (for example, of metals).

33 Having minimised the overall production of radioactive waste, the application of BAT to minimise the activity in gaseous and aqueous discharges tends to transfer activity to low (and intermediate – see below) level solid waste. This is in line with the principle of preferred use of 'concentrate and contain' over 'dilute and disperse' (DECC, 2009). There is little opportunity to reduce the activity of this waste, except by decay storage when the waste contains radionuclides with short half-lives. However, the volume of LLW requiring final disposal can be reduced by using techniques such as waste sorting and segregation, compaction, incineration, removal of surface contamination, re-use and recycling.

34 A schematic of solid AP1000 waste management is given in Figure 3.5-2 of the ER.

35 Waste treatment of LLW is described in section 3.5.7.1 of the ER. LLW will be brought into the radwaste building and sorted to segregate the waste. Whenever possible, Westinghouse claims that waste items will be decontaminated to the extent that allows free release and handling as conventional waste. It also states that compactable LLW items will be sorted and compacted in metal 200 litre drums and non-compactable items will be cut into pieces to allow packing into metal 200 litre drums.

36 Westinghouse states in ER Section 3.5.7.1 that contaminated material that may arise from equipment replacement parts, tools and other metallic, plastics or cloth parts from outage operations would normally be classified as LLW. However, in the event that they were initially classified as ILW, the AP1000 plant includes provisions for the decontamination of these types of materials so that they can be decontaminated to a LLW category if feasible.

37 A schematic of the LLW processing in the radwaste building is given in Figure 3.5-9 of the ER.

38 In section 3.5.7.1 of the ER, Westinghouse states that full drums containing LLW will be assayed with a low resolution gamma spectroscope (LRGS) and placed into half height ISO (HHISO) containers. HHISO containers will be stored on site in the LLW buffer store before being shipped to the LLWR. Westinghouse states in its IWS that the combined capacity for HHISO containers within the buffer store and the radwaste building will provide up to two years of waste arisings. Off-site incineration is considered for certain LLW, for example, waste oil. Solid LLW disposal routes are shown in Figure 3.5-10 in the ER and a schematic of LLW oil disposal is in Figure 3.5-12 of the ER.

39 In section 3.5.1.3 of the ER, Westinghouse states that a range of appropriate options for waste treatment, such as evaporation, drying, incineration and cement encapsulation, were considered at an optioneering workshop. It documented the results of this workshop and the chosen options were substantiated. Further details of this (which Westinghouse also calls its BAT assessment) are given in section 3.5.5 of the ER. There is a schematic of LLW options in Figure 3.5-3 of the ER. The study recommended that compaction is adopted as the design option for the treatment of LLW. There is also a schematic of the summary of the selected BAT treatment systems for ILW and LLW waste in Figure 3.5-8 of the ER.

40 Disposal of LLW is briefly discussed in section 3.5.9.1 of the ER. Westinghouse will dispose of LLW to the LLWR. Westinghouse's IWS assumes that the national LLWR is available within two years of site operations commencing.

41 Westinghouse has completed LLWR form D1s (Request for Agreement in Principle to dispose of radioactive waste at the LLWR) for each of the AP1000 LLW streams. These forms describe the nature of the process producing the waste, the type of radioactive waste generated, the physical and chemical form of the waste, and its radiological characteristics.

42 Westinghouse has provided us with signed form D1s from the LLWR, giving agreement in principle for the treatment / disposal of the following LLW:

a) CPS resin;

b) general LLW;

c) waste oil;

d) steam generator sludge.

43 The LLWR recognises that Westinghouse form D1 applications represent assumed waste disposals at some point in the future and, as such, it cannot guarantee future capacity today. However, the LLWR has assessed Westinghouse's application against its current arrangements and can give agreement in principle on the basis that this waste would be suitable for treatment / disposal against its current arrangements.

44 Although form D1s have been completed for all AP1000 operational LLW (condensate polishing (CPS) resin, general LLW, waste oil and steam generator sludge), Westinghouse has identified waste streams that are likely to be suitable for incineration to minimise the waste sent to the LLWR. The CPS resin form D1 was included as a contingency, as generally they are not expected to be contaminated, and are proposed to be treated in the high temperature incinerator at Fawley. The form D1 considers the case if the resin contamination prevents it from being accepted at this incinerator.

45 Off-site incineration is also considered for waste oil as described in ER section 3.5.7.1. Waste oil will normally be non-radioactive, however, in the event of the oil becoming contaminated with radioactivity it will be shipped to an appropriate incineration facility (for example, the Tradebe Incinerator at Fawley). Westinghouse has carried out a review of this contaminated oil against the conditions of acceptance of this incinerator and shown that they can be met. However, Westinghouse states in section 3.5.7.1 that if any waste oil exceeds the radioactivity acceptance thresholds of the incinerator, it will be solidified by mobile plant before being disposed of to the LLWR.

46 Westinghouse has considered the treatment and disposal of large, one-off solid radioactive waste items that could need replacing during the operation of the AP1000. It considers steam generators and reactor pressure vessel heads. Westinghouse states in section 3.5.7.1 that steam generators will be LLW and that they will be reduced in size in a temporary facility, placed in HHISO containers and sent for disposal at the LLWR. Westinghouse states in ER section 3.5.7.1 that the reactor pressure vessel head is not likely to have to be replaced during the operating lifetime but, if it is necessary, it will be treated in a similar way to steam generators.

47 In section 3.5.1.1 in the ER, Westinghouse summarises its waste minimisation strategy. It states that waste minimisation is an inherent part of waste management and that waste is minimised by:

a) the design: The AP1000 was designed with fewer valves, pipes, and other components so less waste will be generated during maintenance activities (repair and replacement) and decommissioning;

b) material selection: For example, the level of cobalt in structures is limited to limit the activation of metal components, and surfaces (including steel wall and floor surfaces) will be sealed to prevent penetration and to facilitate decontamination.

48 In section 3.5.4.1 of the ER, Westinghouse states how the basic AP1000 design principles minimise the creation of LLW during operations and decommissioning, which are:

a) good housekeeping;

b) operating procedures;

c) segregation;

d) volume reduction;

e) sealed surfaces (including steel wall and floor surfaces) to prevent penetration and to facilitate decontamination;

f) limiting the amount of material brought into containment;

g) training all staff allowed to enter radiation controlled areas;

h) providing waste facilities immediately outside of the radiation controlled areas, for the disposal of unnecessary packaging materials;

i) providing tool stores within the reactor containment area (RCA), to prevent contamination of clean tools brought in from outside;

j) testing filter performance to ensure filters are only replaced when necessary;

k) providing radioactive waste advice on radiation work permits.

49 In section 3.5.5 of the ER, Westinghouse provides details of the BAT assessment that has been carried out on the radwaste treatment system. This addressed the waste activities from the transportation point of the 'nuclear island' through to dispatch to the ILW storage before disposal or to the LLW disposal.

50 Westinghouse states in its IWS that within the design of AP1000, there are many features that facilitate the eventual decommissioning of the plant. For example:

a) reduced equipment numbers reduce the amount of waste that needs managing;

b) carefully selecting materials reduces activation of equipment and structure;

c) reduction in activated corrosion products by improved control of primary circuit water chemistry (ph range; 6.9-7.4) and suitable dosing regimes; for example, zinc acetate.

51 Westinghouse has provided evidence in its BAT assessment that BAT has been used to prevent and minimise at source generation of radioactive wastes for the AP1000. This includes information such as how the control of the choices of materials in contact with the primary coolant leads to a reduction in the production of corrosion products.

3.6 Management and Disposal of Intermediate Level Waste

52 In this section we cover our assessment of the management of intermediate level radioactive waste (ILW). ILW is waste with activity levels exceeding the upper boundaries for low level waste, but which does not require heat generation to be accounted for in the design of disposal or storage facilities. There are currently no final disposal facilities for ILW in the UK. However, the Government has stated (BERR, 2008) that it is satisfied that:

a) a geological disposal facility (GDF) would provide a possible and desirable mechanism for disposing of higher level waste (both from a new nuclear programme and existing legacy waste);

b) there are feasible and long-term mechanisms through the Managing Radioactive Waste Safely (MRWS) (Defra et al, 2008) programme for identifying a suitable site and for constructing a geological disposal facility.

53 Although a permit for final disposal may not be required for a considerable time, we expect Westinghouse to show now whether the waste is:

a) likely to be suitable for disposal in a geological repository;

b) will be appropriately managed in the interim, so as not to prejudice its ultimate disposal.

54 A schematic of solid AP1000 waste management is given in Figure 3.5-2 of the ER. Waste treatment of ILW is described in section 3.5.7.2 of the ER and shown in the schematic in Figure 3.5-13.

55 ILW will be segregated on an AP1000 nuclear site in the following ways:

a) ion exchange and spent activated carbon will be monitored and sent to spent resin tanks;

b) replacement filter cartridges and any ILW filters will be placed in a radioactive waste management directorate (RWMD) approved box.

56 In section 3.5.1.3 of the ER, Westinghouse states that a range of appropriate options for waste treatment, such as evaporation, drying, incineration and cement encapsulation, was considered at an optioneering workshop. It documented the results of this workshop and the chosen options were substantiated. Further details of this (which Westinghouse also calls its BAT assessment) are given in section 3.5.5 of the ER. There is a schematic of ILW organic resin treatment options in Figure 3.5-4 of the ER and a schematic of ILW filter treatment options in Figure 3.5-7 of the ER. There is also a schematic of the summary of selected BAT for ILW and LLW waste in Figure 3.5-8 of the ER. The solid ILW will be immobilised in a cementitious grout within a RWMD approved container (drums or boxes). Westinghouse's BAT assessment concluded that solid ILW should be encapsulated in cement, stored and ultimately disposed of to a national ILW repository.

57 Hence, the spent ion exchange resin and/or activated carbon will be immobilised in a cementitious grout formulation within a RWMD approved drum. The spent filters, etc., will be immobilised in a cementitious grout formulation within a RWMD approved box. The waste encapsulation will be carried out using a mobile encapsulation facility on a campaign basis. The ILW waste packages will be subject to monitoring checks using a high resolution gamma spectroscope (HRGS) to produce a 'fingerprint' of the activity concentrations within the waste packages. Once the cement in the containers has set and passed quality assurance checks, they will be transported to the on-site ILW storage building. The boxes and drums will be stored here until a national ILW repository becomes available. A schematic of ILW treatment and disposal is given in Figure 3.5-13 of the ER.

58 Westinghouse claims that the ILW store will be designed for a total inventory of 60 years of operational waste arisings from one AP1000 unit and it will have a 100-year design life.

59 ILW will be stored on the sites in dedicated building(s) until a final disposal site for ILW is opened in the UK.

60 Westinghouse states in ER section 3.5.8.2 that when a national ILW repository becomes available, it will monitor the waste packages by HRGS before transportation. If the HRGS result of a package indicates that the radionuclides in the package have decayed such that the package could be LLW, the package will be temporarily placed in a LLW storage area. If suitable, these will be disposed of to the LLWR, which will reduce the final quantities of ILW to be disposed of. However, Westinghouse expects that all waste packages sent to the ILW store will remain ILW.

61 Westinghouse's proposals for storage of ILW are based on current practice. However, the regulators have requested further information about the proposed storage facilities to support the long-term safe storage of ILW and to ensure ILW does not degrade over the long storage period.

62 Disposability of operational ILW is briefly discussed in section 3.5.9.2 of the ER. In order to assess the disposability of ILW, Westinghouse provided the Nuclear Decommissioning Authority (NDA) with a datasheet for each of the AP1000 waste streams. Each datasheet included information on the nature of the waste stream, rate of arising, proposed matrix, package type, physical and chemical composition and radionuclide inventory, package heat output and external dose rate. Westinghouse has provided us with datasheets for the following operational waste types:

a) filter cartridges (ILW);

b) primary resins (ILW);

c) mixed resins (ILW).

63 Westinghouse has provided us with a datasheet for decommissioning waste.

64 Westinghouse has obtained and provided a view from the RWMD of the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source) on the disposability of its proposed arisings of ILW. RWMD concluded that compared with legacy waste, no new issues arise that challenge the fundamental disposability of the waste expected to arise from operation of the AP1000.

65 The regulators requested further information from Westinghouse in December 2009 on the disposability of spent fuel and ILW. We received Westinghouse's response on 1 March 2010. Our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d) considers both Westinghouse's opinion of the RWMD assessment, and the RWMD assessment. It concludes that subject to a satisfactory demonstration that ILW can be stored safely for the necessary period of time without significant degradation, there should be no reason at this stage to believe that any ILW will not be disposable in a suitably designed and located GDF. Please refer to this report for more information (Environment Agency, 2010d).

66 HSE is reviewing information on long term storage of ILW in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document.

67 Westinghouse states in section 3.5.4.2 of the ER that ILW will be minimised by the following activities:

a) optimum operation of the reactor in terms of power generation per tonne of fuel;

b) select fuel with minimal potential for fuel defects, thereby minimising the radioactive isotope contamination of the primary cooling water circuit. This will reduce load being treated by the ion exchange resin beds and hence the volume of ILW;

c) fuel is received and carefully inspected for any imperfections;

d) minimisation of plant shutdowns;

e) use of grey rods for mechanical shim control;

f) use of canned coolant pumps eliminates seal leaks and creation of radioactive wastewater;

g) selecting materials with a composition low in cobalt;

h) using zinc addition for corrosion control;

i) selecting ion exchange media to give optimum decontamination factor (DF), which will:

   i) minimise the number of ion exchange media changes required and reduce the waste volume;

   ii) give flexibility in routing effluent through the different ion exchange beds to optimise resin uptake;

j) testing filter performance to make sure filters are only replaced when necessary;

k) segregation procedures to prevent dilution of ILW streams by mixing them with LLW streams;

l) formulation trials to determine optimum blend ratio producing the optimum number of waste packages;

m) operating procedures.

68 Westinghouse states in its radioactive waste management case (RWMC) document that minimisation is an important initial step in waste management, and AP1000 operational procedures will seek to design, construct, operate, and decommission the plant in such a way that both the waste volume and radioactivity are minimised. It states that this will be achieved on the AP1000 nuclear site by activities such as:

a) optimum operation of the reactor in terms of power generation per tonne of fuel, minimise fuel defects, and hence, minimise the activity of primary cooling water circuit, which in turn, minimises volumes of spent ion exchange resin;

b) good housekeeping: for example, minimising the amount of material brought into containment;

c) selecting ion exchange media to give optimum decontamination factor, which will minimise the number of ion exchange media changes required and reduce the waste volume;

d) formulation trails to determine blend ratio producing the optimum number of waste packages;

e) operating procedures.

69 Westinghouse has provided evidence in its BAT assessment that BAT has been used to prevent and minimise at source generation of radioactive wastes for the AP1000. This includes information such as how the control of the choices of materials in contact with the primary coolant leads to a reduction in the production of corrosion products.

3.7 Compliance with our REPs

70 The following REPs were considered in our assessment of Westinghouse's LLW and ILW:

a) Principle RSMDP3 – Use of BAT to minimise waste: The best available techniques should be used to ensure that production of radioactive waste is prevented and where that is not practicable minimised with regard to activity and quantity.

b) Principle RSMDP8 – Segregation of wastes: The best available techniques should be used to prevent the mixing of radioactive substances with other materials, including other radioactive substances, which might where such mixing compromise subsequent effective management or increase environmental impacts or risks.

c) Principle RSMDP9 – Characterisation: Radioactive substances should be characterised using the best available techniques so as to facilitate their subsequent management, including waste disposal.

d) Principle RSMDP10 – Storage: Radioactive substances should be stored using the best available techniques so that their environmental risk and environmental impact are minimised and that subsequent management, including disposal is facilitated.

e) Principle RSMPD15 – Requirements and conditions for disposal of wastes: Requirements and conditions that properly protect people and the environment should be set out and imposed for disposal of radioactive waste. Disposal of radioactive waste should comply with imposed requirements and conditions.

71 The table below summarises whether these REPs have been addressed in Westinghouse's submission:

REP number	REP title & Information in submission
RSMDP3	**Use of BAT to minimise waste** See descriptions in 'Management and Disposal of Low Level Waste' and 'Management and Disposal of Intermediate Level Waste' sections above. Westinghouse has provided basic evidence of how they will minimise the disposal of LLW and ILW. This includes appropriate characterisation and segregation. Further detailed evidence is required at site-specific permitting.
RSMDP8	**Segregation of wastes** Westinghouse state in section 3.5.7.1 of the ER that LLW will be brought into the radwaste building and sorted to segregate the waste. Whenever possible, Westinghouse claims that waste items will be decontaminated to the extent that allows free release and handling as conventional waste. They also state that compactable LLW items will be sorted and compacted in metal 200 litre drums and non-compactable items will be cut into pieces to allow packing into metal 200 litre drums. With respect to large one-off items, Westinghouse states in section 3.5.7.1 that steam generators will be LLW and that they will be reduced in size in a temporary facility, placed in HHISO containers and sent for disposal at the LLWR. Westinghouse states in ER section 3.5.7.1 that the reactor pressure vessel head is not likely to have to be replaced during the operating lifetime but, if it is necessary, it will be treated in a similar way to steam generators. Westinghouse state in section 3.5.7.2 of the ER and shows in the schematic in Figure 3.5-14 that ILW will be segregated on an AP1000 nuclear site in the following ways: • Ion exchange and spent activated carbon will be monitored and sent to spent resin tanks. • Replacement filter cartridges and any ILW filters will be placed in a RWMD approved box.
RSMDP9	**Characterisation** See 'RSMDP3' and 'RSMDP8' above.
RSMDP10	**Storage** See descriptions in 'Management and Disposal of Low Level Waste' and 'Management and Disposal of Intermediate Level Waste' sections above. Westinghouse has described its buffer storage arrangements for LLW and its storage arrangements for ILW prior to disposal. Waste will be treated and conditioned using proven and recognised techniques. However, HSE will be looking at Westinghouse's plans for the conditioning of wastes produced by an AP1000 in more detail as part of its Step 4 assessment, and our final decision will be informed by this work.

REP number	REP title & Information in submission
RSMPD15	**Requirements and conditions for disposal of wastes** See descriptions in 'Management and Disposal of Low Level Waste' and 'Management and Disposal of Intermediate Level Waste' sections above. The design is not expected to produce LLW for which there is no foreseeable disposal route. Westinghouse has demonstrated that the waste streams would meet the criteria for disposal in a LLW facility or an incineration facility. The design is not expected to produce ILW for which there is no foreseeable disposal route. However, the regulators need more information on the potential for degradation of ILW over the longer term that might affect its disposability and safe storage. Westinghouse provided information on 1 March 2010. Our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d) concludes that subject to a satisfactory demonstration that ILW can be stored safely for the necessary period of time without significant degradation, there should be no reason at this stage to believe that any ILW will not be disposable in a suitably designed and located GDF. HSE is reviewing Westinghouse's information in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document. Westinghouse has obtained and provided a view from the NDA (as the UK authoritative source in providing such advice) on the disposability of its proposed arisings of ILW. RWMD concluded that compared with legacy wastes, no new issues arise that challenge the fundamental disposability of the wastes expected to arise from operation of the AP1000. Further information on the disposability of ILW can be found in our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d).

3.8 Compliance with Table 1 in our Process and Information Document

72 Sections 2.1, 2.4 and 1.5 in Table 1 of the P&ID were considered in our assessment of Westinghouse's LLW and ILW. The table below summarises whether these requirements have been addressed in Westinghouse's submission:

Section number	Description of requirement & Information in submission
2.1	**A description of how radioactive wastes will arise, be managed and disposed of throughout the facility's lifecycle.** See 'Creation of Solid Waste' section above. This shows that Westinghouse has provided a description of how radioactive solid wastes will arise. All LLW and ILW waste streams that an AP1000 will typically produce have been identified by Westinghouse. See 'Management and Disposal of Low Level Waste' and 'Management and Disposal of Intermediate Level Waste' sections above. This shows that Westinghouse has provided a description of how radioactive solid wastes will be managed and disposed of. The design is not expected to produce LLW for which there is no foreseeable disposal route. Westinghouse has demonstrated that the waste streams would meet the criteria for disposal in a LLW facility or an incineration facility. The design is not expected to produce ILW for which there is no foreseeable disposal route. However, the regulators need more information on the potential for degradation of ILW over the longer term that might affect its disposability and safe storage. Westinghouse provided information on 1 March 2010. Our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d) concludes that subject to a satisfactory demonstration that ILW can be stored safely for the necessary period of time without significant degradation, there should be no reason at this stage to believe that any ILW will not be disposable in a suitably designed and located GDF. HSE is reviewing Westinghouse's information in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document. Westinghouse has obtained and provided a view from the NDA (as the UK authoritative source in providing such advice) on the disposability of its proposed arisings of ILW. RWMD concluded that compared with legacy wastes, no new issues arise that challenge the fundamental disposability of the wastes expected to arise from operation of the AP1000. Further information on the disposability of ILW can be found in our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d). Westinghouse has considered decommissioning radioactive solid waste.

Section number	Description of requirement & Information in submission
2.4	**Design basis estimates and substantiation of annual arisings of solid radioactive waste during operation and decommissioning. Wastes should be identified in terms of category (HLW, ILW, LLW), physico-chemical characteristics and proposed disposal route (if any). Quantification should be in terms of activity of key individual radionuclides and overall groupings of radionuclides (e.g. total alpha), mass and volumes.** See 'Creation of Solid Waste', 'Management and Disposal of Low Level Waste' and 'Management and Disposal of Intermediate Level Waste' sections above. This shows that Westinghouse has provided estimates of annual arisings of solid radioactive waste during operation and decommissioning. Wastes have been identified in terms of category, physico-chemical characteristics and proposed disposal route. Quantification is in terms of activity of key individual radionuclides and overall groupings of radionuclides (e.g. total alpha), mass and volumes. The estimates in Westinghouse's submission for the volumes of LLW and ILW appear to be reasonable for the AP1000. These estimates were derived by Westinghouse using information from consultations with experienced personnel who have worked in the design of the AP1000 and worked on existing plants. Additionally, Westinghouse has provided a comparison of its estimated solid radioactive waste arisings against available operating plant experience in its response to TQ-AP1000-383. This supplementary information provides confidence that the estimates are realistic for the UK AP1000. Additionally, the Environment Agency and HSE attended a presentation by Westinghouse in February 2010 on its processes for deriving data on radioactive wastes where further confidence was gained. These arisings of LLW and ILW are consistent with those of comparable reactors around the world (Isukul, 2009). However, the arisings of LLW and ILW exceed the European Utility Requirement objective of less than ≤ 50 m^3 per 1000 MWe plant-year of operation (EUR, 2001).
2.4	**The requesting party should obtain, and provide, a view from the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source in providing such advice) on the disposability of any proposed arisings of ILW.** See descriptions in 'Management and Disposal of Low Level Waste' and 'Management and Disposal of Intermediate Level Waste' sections above. Westinghouse has obtained and provided a view from the NDA (as the UK authoritative source in providing such advice) on the disposability of its proposed arisings of ILW. RWMD concluded that compared with legacy wastes, no new issues arise that challenge the fundamental disposability of the wastes expected to arise from operation of the AP1000. Further information on the disposability of ILW can be found in our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d).

Section number	Description of requirement & Information in submission
1.5	**An analysis should be provided that includes an evaluation of options considered and Shows that the best available techniques will be used to minimise the production and discharge or disposal of waste.** See descriptions in 'Management and Disposal of Low Level Waste' and 'Management and Disposal of Intermediate Level Waste' sections above. Westinghouse has provided basic evidence of how they will minimise the disposal of LLW and ILW. This includes appropriate characterisation and segregation. Further detailed evidence is required at site-specific permitting.

4 Public comments

73 No comments on ILW were received from the public involvement process relating to the AP1000 design during our detailed assessment stage.

5 Conclusion

74 We conclude that:

a) In its submission, Westinghouse describes how LLW and ILW will be generated, managed and disposed of throughout the facility's lifecycle.

b) Westinghouse has identified all LLW and ILW waste streams that an AP1000 will typically produce.

c) Waste will be treated and conditioned using proven and recognised techniques. However, HSE will be looking at Westinghouse's plans for the conditioning of waste produced by an AP1000 in more detail as part of its Step 4 assessment, and our final decision will be informed by this work.

d) The design is not expected to produce LLW or ILW for which there is no foreseeable disposal route. However, the regulators need more information on the potential for degradation of ILW over the longer term that might affect its disposability and safe storage. Westinghouse provided information on 1 March 2010, which was considered in our assessment report on disposability of ILW and spent fuel (Environment Agency, 2010d). HSE is reviewing this information in its Step 4 assessment. We will continue to work with HSE on this, and this work will inform our decision document.

e) Westinghouse has provided estimates for the annual arisings (during operations and decommissioning) of LLW and ILW. The arisings of LLW and ILW exceed the European Utility Requirement objective of less than 50 m^3 per 1000 MWe plant-year of operation (EUR, 2001), although, these arisings (during operations) are consistent with those of comparable reactors around the world (Isukul, 2009).

f) Westinghouse has provided basic evidence of how they will minimise the disposal of LLW and ILW.

75 However, our conclusion is subject to the following other issues:

a) Disposability of ILW following longer term interim storage pending disposal.

b) Provide evidence at site-specific permitting that the specific arrangements for minimising the disposals of LLW and ILW for each site represents BAT.

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Abbreviations

AP1000™	AP1000 is trademark of Westinghouse Electric Company LLC
BAT	Best available techniques
CFA	Conditions for acceptance
CPS	Condensate polishing
DF	Decontamination factor
ER	UK AP1000 environment report
ERs*.*	Environment report section reference e.g. 3.2.2.2
GDA	Generic design assessment
GDF	Geological disposal facility
HHISO	Half height ISO
HLW	High level waste
HRGS	High resolution gamma spectroscope
HSE	The Health and Safety Executive
ILW	Intermediate level waste
IWS	AP1000 integrated waste strategy document
LLW	Low level waste
LLWR	The national Low level waste repository, near Drigg, Cumbria
LRGS	Low resolution gamma spectroscope
MRWS	Managing Radioactive Waste Safely
NDA	Nuclear Decommissioning Authority
NRC	The United States Nuclear Regulatory Commission
P&ID	Process and information document
PWR	Pressurised water reactor
RCA	Reactor containment area
REPs	Radioactive substances environmental principles
RI	Regulatory issue
RO	Regulatory observation
RP	Requesting party
RWMC	Radioactive waste management cases
RWMD	Radioactive Waste Management Directorate (of NDA)
STUK	Säteilyturvakeskus - The Radiation and Nuclear Safety Authority of Finland
TQ	Technical query
WEC	Westinghouse Electric Company LLC

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