Generic design assessment

AP1000 nuclear power plant design by Westinghouse Electric Company LLC

Assessment report
Spent fuel

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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: Section 1.4 A proposed **waste and spent fuel strategy** based on the expected waste generation and management practices throughout the facility lifecycle Section 2.5 A description of **how spent fuel will be managed** and the quantities that will arise throughout the facility's lifecycle
Radioactive Substances Regulation Environmental Principles[2]	The following principles are relevant to this assessment: RSMDP1 – Radioactive Substances Strategy: A strategy should be produced for the management of all radioactive substances 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. 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. RSMDP14 – Record Keeping. Sufficient records relating to radioactive substances and associated facilities should be made and managed so as to facilitate the subsequent management of those substances and facilities; to demonstrate whether compliance with requirements and standards has been achieved; and to provide continuing assurance about the environmental impact and risks of the operations undertaken, including waste disposal. RSMDP15 – Requirements and conditions that properly protect people and the environment shall be set out and imposed for disposal of radioactive waste. Disposal of radioactive waste shall comply with imposed requirements and conditions.
Report author	Dr Colette Grundy

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 the Environment Agency's assessment of the proposals made by Westinghouse Electric Company LLC (Westinghouse) for spent fuel management based on information submitted by Westinghouse in its Environment Report (ER) and supporting documents.

2 The Joint Regulators for Generic Design Assessment (GDA), the HSE and the Environment Agency, have worked together closely to review Westinghouse's spent fuel management proposals in GDA. HSE are responsible for regulation of storage of spent fuel and Environment Agency regulate disposal of spent fuel. Our assessment has involved review of Westinghouse's GDA submissions and, in particular its Integrated Waste Strategy (IWS), BAT report, Radioactive Waste Management Case Evidence Report for HLW, and the NDA RWMD Disposability Assessments, including a Westinghouse opinion of the Nuclear Decommissioning Authority (NDA) Radioactive Waste Management Directorate's (RWMD) findings.

3 This assessment aims to establish that Westinghouse has an adequate strategy for spent fuel management, and that spent fuel will be managed so that it will be suitable for disposal at a geological disposal facility (GDF).

4 We have examined Westinghouse's GDA submissions, and found that Westinghouse give consideration to operating strategies in regard to spent fuel generation. The strategy proposed by Westinghouse for managing spent fuel following its removal from the reactor, is to transfer the spent fuel to the spent fuel pool for storage and initial cooling for a period of around 18 years. The fuel is then proposed to be transferred to an interim storage facility (a dry interim store is proposed as a reference case for potential operators) until such time a geological disposal facility becomes available for direct disposal. Westinghouse have provided supporting information on dry storage

5 We conclude that in its submission, Westinghouse describe how spent fuel will arise, be managed and disposed of throughout the facility's lifecycle. Westinghouse provide information on the fuel composition and characteristics, and expected fuel burn up, and quantities of spent fuel that will arise. Information is provided in the submission and supporting documents on short and long-term management proposals for spent fuel. Westinghouse have obtained a view from the RWMD of the NDA on the disposability of the fuel and have provided an opinion to the regulators.

6 Westinghouse provided detailed responses in regard to disposability in March 2010, which were considered in our assessment report on disposability of spent fuel.

7 We need more information on the longer term storage of the fuel to understand whether there is any potential for degradation of the fuel over the longer term that might affect its disposability. This is consistent with the HSE requirement for a satisfactory demonstration that spent fuel can be stored safely for the necessary period of time without significant degradation. The regulators have requested information about long term storage and this information is being provided. HSE will review this information in its Step 4 assessment. We will continue to work with HSE on these issues, and this work will inform our decision document. Therefore, our conclusion is subject to the potential GDA Issue:

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

8 Our findings on the wider environmental impacts and waste management arrangements for the AP1000 reactor may be found in our Consultation Document (Environment Agency, 2010b).

2 Introduction

9 We set out in our Process and Information Document (P&ID, Environment Agency, 2007) the requirements for a Requesting Party to provide a proposed **waste and spent fuel strategy** based on the expected waste generation and management practices throughout the facility lifecycle. This strategy should have regard to:

a) the UK Government's Sustainable Development Strategy (March 2005) Cm 6467, (Defra, 2005);

b) the objectives of the UK strategy for radioactive discharges (DECC, 2009b);

c) the Review of Radioactive Waste Management Policy, Final Conclusions, Cm2919 July 1995 (DETR, 1995);

d) The Decommissioning of the UK Nuclear Industry's Facilities (decommissioning policy) (DTI, 2004); and

e) our Radioactive Substances Regulation Environmental Principles (REPs) (Environment Agency, 2010a).

10 Our P&ID also requires a description of **how spent fuel will be managed** and the quantities that will arise throughout the facility's lifecycle. This should include:

a) new fuel composition and characteristics;

b) expected fuel burn up and ratings;

c) short and long term management proposals including any for off site management or disposal.

11 If the management options include direct disposal, 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 the spent fuel.

12 We published our Radioactive Substances Regulation Environmental Principles in 2010 (Environment Agency, 2010a) and principles on radioactive substance strategy, use of BAT to minimise waste, storage, record keeping and requirements and conditions that properly protect people and the environment are relevant to this topic.

13 This assessment aims to establish that Westinghouse have an adequate strategy for spent fuel management, and that spent fuel will be managed so that it will be suitable for disposal at a geological disposal facility. This assessment considers in detail Westinghouse's proposals for spent fuel management.

14 This assessment comprises a review of Westinghouse's submission on spent fuel. The Joint Regulators have worked closely to review Westinghouse's proposals for spent fuel management in GDA. Our assessment is performed on a sampling basis and has involved review of Westinghouse's GDA submissions including the Environment Report (ER) and key supporting documents, namely the Integrated Waste Strategy (IWS), BAT report and Radioactive Waste Management Case (RWMC) evidence report for spent fuel.

15 We assessed information contained in the ER but found that while much improved from the original submission it still lacked the detail we require including an integrated waste strategy for waste and spent fuel, and detailed proposals for spent fuel management. We raised Regulatory Observations (ROs) jointly with HSE on Westinghouse that had actions to provide:

a) Integrated Waste Strategy, BAT case and evidence to support a Radioactive Waste Management Case (RO-AP1000-34);

b) Long Term Storage (RO-AP1000-74) (HSE)

c) Disposability of Spent Fuel and ILW (RO-AP1000-60)

16 We raised 42 Technical Queries (TQs) on Westinghouse during our assessment. The following TQs, some of which were raised jointly with HSE, were relevant to this report:

a) TQ-AP1000-211 Discharge of Actinides

b) TQ-AP1000-232 AP1000 Intermediate Level Waste

c) TQ-AP1000- 329 Encapsulation of Spent Fuel prior to Disposal.

17 Westinghouse responded to all the ROs and TQs. They reviewed and updated the ER in April 2010 to include all the relevant information provided by the ROs and TQs.

3 Assessment

3.1 Assessment Methodology

18 The basis of our assessment was to:

a) review appropriate sections of the ER and its supporting documents including the Integrated Waste Strategy (IWS), BAT report, and Radioactive Waste Management Case (RWMC) evidence report for spent fuel;

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

c) carry out a site visit to an operating Westinghouse PWR with an interim dry spent fuel storage facility;

d) raise Regulatory Observations and Technical Queries where we believed information provided by Westinghouse was insufficient; and,

e) decide on any potential exclusions to carry forward from GDA.

3.2 Assessment Objectives

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

a) Does Westinghouse provide an adequate integrated waste and spent fuel strategy

b) Does Westinghouse provide information on new fuel composition and characteristics, and proposed fuel burn up

c) Does Westinghouse provide information on spent fuel quantities and give consideration to operating strategies in regard to spent fuel generation

d) Does Westinghouse provide information on the short and long term management proposals for spent fuel

e) Are the spent fuel arisings from an AP1000 disposable?

20 We expect new nuclear power plant designs to be developed in line with a radioactive waste and spent fuel strategy that seeks to:

a) minimise the production of radioactive waste;

b) manage unavoidable waste and spent fuel to achieve an optimal level of protection for people and the environment.

21 Our radioactive substances regulation environmental principles (REPs) (Environment Agency, 2010a) set out the issues that this type of strategy should take into account. For new nuclear power plant designs, the strategy also needs to be consistent with recent government statements (BERR, 2008) that:

a) the disposal of intermediate level radioactive waste (ILW) to a future geological repository, from any new nuclear power stations, is unlikely to occur until late this century;

b) any nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed.

22 There are currently no final disposal facilities for spent fuel in the UK. However, the Government has stated (BERR, 2008) that it is satisfied that:

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

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

23 Although a permit for final disposal may not be required for a considerable time, we expect Westinghouse to show now whether spent fuel 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.

24 We expect spent fuel storage to be required for around 100 years until a geological disposal facility is available. The Regulators need to see that spent fuel can be safely stored and managed to avoid degradation over time such that it can remain in a form acceptable for disposal in a repository.

3.3 Westinghouse documentation

25 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-012	GDA : Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the Westinghouse Advanced Passive PWR (AP1000)	
UN REG WEC 00098	GDA; Disposability Assessment for the Westinghouse PWR (AP1000)- Westinghouse Electric Company Opinion dated 19 October 2009	
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-056	UK AP1000 Radioactive Waste Management Case Evidence Report for High Level Waste	0

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

a) ER sub-chapter 6.2 section 1.2.1 = ERsc6.2s1.2.1;

3.4 Waste and Spent Fuel Strategy

27 Westinghouse produced the Integrated Waste Strategy, IWS, in response to RO-AP1000-34.A1. Westinghouse's IWS outlines its current strategy for managing radioactive and non-radioactive waste, including spent fuel arising from various stages of the lifecycle for AP1000, such as operation and decommissioning.

28 Section 3.5.1 of the ER provides an overview of the IWS that Westinghouse has developed to ensure that radioactive waste and materials generated, including spent fuel, are managed to be compatible with anticipated future NDA facilities for disposal. Westinghouse has assumed that it will be able to use current practices for spent fuel packaging when the AP1000 is in operation as it indicates NDA has not been able to provide information on the spent fuel packages it will accept. These assumptions relate to container designs and sizes and acceptable waste forms for spent fuel assemblies. Westinghouse continues to liaise with NDA on these matters during the GDA process.

29 The strategy proposed by Westinghouse for managing spent fuel following its removal from the reactor, is to transfer the spent fuel to the spent fuel pool for storage and initial cooling for a period of around 18 years. The fuel would then be transferred to an interim spent fuel dry store until a geological disposal facility becomes available for direct disposal. More detailed information on new and spent fuel, including spent fuel management proposals is presented later in this report.

30 Westinghouse's proposals for interim dry spent fuel storage are based on the Holtec International HI Storm 100U underground system. There are a large number of independent spent fuel storage installations in the United States that are licensed and operating for dry spent fuel storage. These systems are also used in Europe to maintain the fuel in a dry inert atmosphere.

31 The IWS notes that there is a spent fuel interim store to store all spent fuel assemblies generated by the reactor until the end of this century before final disposal. Westinghouse take account of Government policy in their IWS including assumptions that spent fuel will be declared as waste and will not be reprocessed, and that it will be stored on site and then disposed of to the geological disposal facility.

32 Interim storage may be required potentially beyond 100 years to cover the lifetime of reactor operations (including the final emplacement of fuel to interim storage, following an initial cooling period in a pool after reactor operations cease), the time to reduce the heat generation of the fuel, and the potential for refurbishment of the store(s).

33 The regulators requested further information about long-term storage from Westinghouse, see later. HSE will review this information in its Step 4 assessment. We will continue to work closely with HSE on this issue, and this work will inform our final decision.

34 Westinghouse provides information in the BAT report on the measures it has incorporated in the design and use of fuel materials, and reactor controls in order to retain activity in the fuel.

35 RO-AP1000-34 also required Westinghouse to provide evidence to demonstrate how it could meet regulatory expectations for a radioactive waste management case. In response to RO-AP1000-34.A4, Westinghouse produced a Radioactive Waste Management Case (RWMC) evidence report for HLW to demonstrate how it could meet regulatory expectations, and identified the information required to produce the RWMC for spent fuel (HLW).

36 The RWMC is to demonstrate the longer term safety and environmental performance of wastes for the planned management from the stage of generation to conditioning to the form which will be suitable for storage and eventual disposal.

37 The evidence report outlined more information on the plans for longer term interim spent fuel storage, and identified areas where more information was needed including future research requirements.

38 The report covers spent fuel assemblies and discusses the waste management process from cooling in the spent fuel pool to dry storage and transport packaging for transfer to the disposal facility. The plant safety case is described with reference to onsite radioactive waste management provisions, and arrangements for the monitoring regime while the spent fuel is stored in the pool. Waste minimisation for spent fuel is achieved by selection of the optimum burn up rate to minimise waste products, and the quality of the fuel is claimed to minimise waste products and long lived radionuclides. The report considers the long term performance and potential for degradation of the canisters used for dry spent fuel storage.

39 The report identifies areas being addressed by current research in terms of long term performance of the waste form and for the waste containers including potential for degradation of the containers, and potential gas generation from the wastes over the long term. Also the specification for the disposal waste package, and demonstration that conditioned wastes will remain within the agreed specification for final disposal throughout storage.

40 The evidence report identifies an area where further research is required in regard to encapsulation and disposability of spent fuel. Westinghouse state confidence in managing long term storage on the basis of international experience gained in spent fuel storage, and on the development of dry storage systems where the spent fuel is kept in an inert sealed atmosphere.

41 Information is provided in Westinghouse's IWS about decommissioning waste and specific features of the AP1000 plant that have been designed to facilitate decommissioning. The IWS notes the longer term interim spent fuel store will be decommissioned following transfer of spent fuel to the GDF, and provides some general information on decommissioning of the store. This will require the use of temporary facilities to handle the wastes arising as a result of dismantling the spent fuel store. The Holtec wastes will comprise the steel closure lid, steel container and divider shells, concrete support foundation and top surface pad. The Holtec dry storage system materials were selected to ensure no chemical, galvanic, or other reactions among the materials of the HI-Storm 100U system, their contents and the operating environment. The steel and concrete wastes arising from the spent fuel store will be decontaminated. Following decontamination, there may be ILW, LLW and non radioactive i.e. uncontaminated materials.

42 The IWS is consistent with recent government statements (BERR,2008) in relation to spent fuel, as Westinghouse has made the following assumptions:

a) Spent fuel will be declared as waste and will not be processed.

b) Spent fuel will be stored on site followed by disposal to the proposed geological disposal facility (GDF) at the appropriate time.

43 **We have concluded that:**

a) **Westinghouse has provided a reasonable strategy for managing spent fuel that will be produced by the AP1000.**

b) **The spent fuel strategy is consistent with recent government statements (BERR, 2008) and our REPs (Environment Agency 2010a), in particular RSMDP1 Radioactive Substances Strategy.**

3.5 Creation of spent fuel

44 The AP1000 reactor core comprises 157 fuel assemblies. Each fuel assembly consists of 264 fuel rods in a 17x17 square array. The fuel rods consist of pellets of slightly enriched uranium dioxide in a zirconium based alloy, Zirlo tubing, which is plugged and seal welded at the ends to encapsulate the fuel. The fuel rods include integral fuel burnable absorbers which may be boride coated fuel pellets, or fuel pellets containing gadolinium oxide mixed with uranium oxide. The reactor control system uses rod cluster control assembles, RCCAs, and grey rod cluster assemblies as burnable absorber rods. The assemblies include rodlets made from silver/indium/cadmium alloys clad in stainless steel. Core reactivity is controlled using boric acid which acts as a chemical poison dissolved in the coolant, rod cluster control assemblies, RCCAs, grey rod cluster assemblies and burnable absorbers. The initial enrichment of new fuel is up to 4.95 per cent in weight uranium 235.

45 New fuel is stored in the new fuel storage facility within the auxiliary building fuel handling area. New fuel assemblies are moved by the new fuel assembly handling tool into the new fuel assembly inspection area. Following inspection, the accepted new fuel assemblies are stored in the new fuel storage rack (and the spent fuel pool in the case of first time fuelling). The new fuel storage rack includes storage locations for 72 fuel assemblies with the maximum design basis enrichment. The racks include integral neutron absorbing material to maintain sub-criticality. The rack layout provides a minimum separation between adjacent fuel assemblies which is sufficient to maintain a sub-critical array even in the event the building is flooded with unborated water, or fire extinguishant aerosols, or during any design basis event. The rack sits on the floor of the new fuel storage pit which is covered to prevent foreign objects from entering the new fuel storage rack.

46 The new fuel handling crane is used to load new fuel assemblies into the new fuel rack and to transfer new fuel assemblies from the new fuel pit into the spent fuel pool. A gated opening connects the spent fuel pool and the fuel transfer canal. A fuel transfer tube connects the fuel transfer canal to the in-containment refuelling cavity.

47 A new fuel elevator in the spent fuel pool lowers the new fuel to an elevation accessible by the fuel handling machine (FHM). The FHM is part of the fuel transfer system which is used to transport up to two fuel assemblies at a time between the fuel handling area in the auxiliary building and the refuelling cavity in the containment building.

48 The FHM is used to perform fuel handling operations in the fuel handling area. Fuel is placed in a basket in the underwater transfer car to pass through the fuel transfer tube into the refuelling cavity.

49 The refuelling machine performs fuel handling operations in the containment building. Fuel is moved between the fuel transfer system and the reactor vessel by the refuelling machine. It withdraws the fuel from the refuelling cavity, moves over the core area and inserts the fuel assembly into a vacant core location. During refuelling the vacant core location is created by first removing a spent fuel assembly.

50 The initial fuel loading consists of 157 fuel assemblies for one AP1000 unit. Refuelling every 18 months requires an average of 68 assemblies for one unit; in fact the range can be between 64 to 68 fuel assemblies depending on fuel enrichment and operating conditions. Spent fuel assemblies are discharged from the reactor at every refuelling outage and are placed into the spent fuel pool. The spent fuel pool has the capacity to store 889 fuel assemblies. Each refuelling offload discharges 68 fuel assemblies. The spent fuel pool has the capacity for 10 refuelling offloads, which is approximately equal to 18 years of operation, plus one full core offload.

51 Westinghouse claims in the ER that the AP1000 reactor design minimises the amount of spent fuel. Westinghouse notes there is extensive worldwide experience of wet storage in a fuel storage pool, and that similar fuel to that proposed for use in AP1000 has been stored for a number of years at Sizewell B and Sellafield.

52 Information is provided in Westinghouse's IWS in terms of quantification of discharge of spent fuel with details of the spent fuel storage pool, and the dry spent fuel storage system.

53 Operating strategies can influence the amount of spent fuel and the radioactivity of the spent fuel. The amount of spent fuel discharged over time is determined by the energy production rate, that is the overall capacity factor including outages, and the discharge burn up limit. Operating utilities may choose from various cycle lengths for AP1000. For example, annual or 18 month cycles. Depending on the requirements of the utility, if the main objective is to reduce the average number of discharge assemblies per year, then on average, an annual cycle would expend fewer assemblies; 40 when compared with 43 on an 18-month cycle. For a plant lifecycle of 60 years, this translates to a generation of 2400 or 2580 spent fuel assemblies for an annual and 18-month cycle respectively. However, depending on the cost of the extra outage every three years, together with the cost of replacement power during the outage, the impact of outage length on average capacity factor etc, this may not be the most economically efficient operation of the reactor core. Westinghouse states that the majority of its utility customers choose the 18-month fuel cycle.

54 The reference 18-month equilibrium cycle feeds and discharges 64 fuel assemblies every 18 months. On average, this means that approximately 43 assemblies per years are discharged and stored in the spent fuel pool. The cycle is based on an assumed 97 per cent capacity factor and a 21 day refuelling outage. This provides a cycle length of approximately 510 effective full power days. The 18-month reference cycle provides close to the lowest overall electrical production costs.

55 The fuel economics and the amount of spent fuel generated are closely correlated. Both are optimised when the fuel cycle is designed with the fuel being discharged from the reactor as close as is reasonable to the licensed discharge burn up of the fuel. The current licensed limit for Westinghouse fuel in the United States is 62,000 MWD/MTU on the lead rod maximum burn up. However, typically a batch average burn up around 50,000 MWD/MTU is achieved based on inter-assembly power variations and variations of assembly power in assemblies within the same batch.

3.6 BAT for Fuel Design

56 Fission products may diffuse from the fuel and pass through the fuel cladding through diffusion or from leaks into the reactor coolant.

57 The design of the fuel rod and the cladding for AP1000 is such that in the event of fuel clad defects, the high resistance of uranium dioxide (UO_2) to attack from water protects against fuel deterioration, although limited fuel erosion can occur. The consequences of defects in the clad are significantly reduced by the ability of uranium dioxide to retain fission products, including those which are gaseous or highly volatile.

58 Zirlo is an advanced zirconium based alloy which has a high corrosion resistance to coolant, fuel, and fission products. Selecting Zirlo cladding materials for the AP1000 minimises defects forming that can result in radioactive releases to the reactor coolant.

59 The BAT forms Westinghouse produced in its BAT assessment report consider tritium, which arises mainly from ternary fission of the uranium fuel followed by diffusion through the fuel pin cladding into the reactor coolant system (RCS). This source of tritium is unavoidable in systems using uranium as a fuel.

60 Using zirconium, zirlo cladding reduces diffusion of tritium compared with other cladding material options. Using reactor controls, including grey rod cluster assemblies, to minimise the need for changes to the concentration of soluble boron, and burnable poisons to limit the amount of boron required, are measures that help to minimise the amount of tritium produced in the reactor coolant. The main measures of reducing the release of tritium relate to the quality of the fuel cladding and minimising fuel defects.

3.7 Management and Disposal of Spent Fuel

61 After spent fuel is removed from the reactor, it will be stored in the spent fuel storage pool to allow radioactive decay to occur and decay heat to be removed. The spent fuel is transferred from the containment building to the spent fuel pool by the fuel transfer system. The fuel handling equipment is designed to handle the spent fuel assemblies underwater from the time they leave the reactor vessel until they are placed into the spent fuel storage pool and eventually in the container for dry storage or shipment from the site.

62 The spent fuel storage pool is located in the auxiliary building and provides storage for spent fuel in borated water with a nominal boron concentration of 2700ppm, to act as a neutron absorber. A spent fuel pool cooling system is provided to remove decay heat generated by the stored fuel assemblies from the water in the spent fuel pool. The decay heat is removed by pumping the high temperature water from within the fuel pool through a heat exchanger, and then returning the water to the pool. A purification system is part of the spent fuel and removes radioactive corrosion products, fission product ions, and dust to maintain low spent fuel pool activity levels during plant operation and to maintain water clarity during all modes.

63 Spent fuel is stored in high density racks which include integral neutron absorbing material to maintain sub-criticality. The racks are designed to store fuel of the maximum design basis enrichment. An assembly cannot be inserted into a location that is full and the design of the racks is such that a fuel assembly cannot be inserted into a location other than a location designed to receive an assembly. The pool contains three region one rack modules, five region two rack modules and five individual defective fuel assembly storage cells. Region 1 racks are used for storage for new fuel and freshly discharged fuel, and region 2 racks for storage of less reactive fuel.

64 The spent fuel assemblies are usually stored in the pool for up to 18 years, which reduces fission product activity and decay heat generation. After this retention period, batches of assemblies are transferred to the HLW dry cask storage facility. Since spent fuel is not expected to be reprocessed, a facility for dry spent fuel storage is being offered to operators as part of the reference design.

65 Westinghouse has proposed the Holtec underground dry spent fuel storage system, the HI STORM 100U system. The spent fuel assemblies are transferred to the storage cask which is designed to shield radiation. The process of loading spent fuel is carried out in a number of steps. The cask handling crane is used to bring in a clean, empty cask to the cask washdown pit where it is washed with demineralised water. The cask lid is removed and stored while the remainder of the cask is washed. The clean empty cask is then properly positioned in the flooded cask loading pit.

66 The fuel handling machine is positioned over the specific fuel assembly to be exported out of the spent fuel storage rack. The fuel assembly is picked up and transported into the cask loading pit. During the transfer process the fuel assembly is always maintained with the top of the active fuel at least 2.9m below the water surface. This ensures that the direct radiation at the surface of the water from the fuel is minimal.

67 Once the fuel transfer process is complete, the lid is placed on top of the cask to provide the required shielding. The cask is then moved to the washdown pit and

cleaned with demineralised water. Decontamination procedures are implemented at this time. When the cask is satisfactorily decontaminated, the cask handling cranes is used to lift it out of the washdown pit in preparation for transfer to the HLW store. During these operations enough water is maintained between plant personnel and fuel assemblies that are being moved to limit dose levels to those acceptable for continuous occupational exposure.

68 The ERs2.3.6 describes the radioactive waste stores and includes the interim store for spent fuel. The spent fuel store is a seismically qualified below ground storage facility including spent fuel flasks, flask loading equipment, suitable flask transportation vehicles and equipment and below ground storage cells. It will be located within the boundary of the nuclear licensed site and Westinghouse proposes to maintain the potential for extending the store in the future. The proposed location was chosen to minimise the transportation distances between the auxiliary building and the spent fuel store and to facilitate safe transfer of the waste.

69 The Holtec HI STORM 100U system is a vertical, ventilated dry spent fuel storage system. Westinghouse and Holtec have confirmed that Holtec equipment can fit in the areas of the AP1000 that need to be reached in order to transfer spent fuel from the spent fuel pool to the underground storage area. The system consists of three primary components:

a) HI STORM 100U underground vertical ventilated module (VVM)- this provides the storage for MPC in a vertical configuration inside a below ground cylindrical cavity. The main function for the VVM is to provide the biological shield and cooling.

b) Multi purpose canister (MPC) – this contains the spent fuel assemblies- the MPCs are identical to those in use in a number of above ground dry spent fuel storage facilities in the USA. The UK Regulators have visited one such above-ground dry spent fuel storage installation as part of an inspection visit during GDA.

c) Hi-TRAC transfer cask which holds the MPC during loading operations.

70 The spent fuel will remain within the HLW store for a determined period of time; at present Westinghouse has allowed up to 100 years. This will enable the heat generating capacity of the spent fuel assemblies to reduce sufficiently to meet the requirements for disposal to the geological disposal facility (GDF).

71 The BAT report includes information from Westinghouse's Utility Partners on spent fuel storage including the CASTOR system. The BAT Assessment report includes solid radioactive wastes and cross refers to the Environmental Report for spent fuel (s3.4 handling and disposal). There was no detailed options assessment presented to substantiate Westinghouse's decision to propose interim dry spent fuel storage using the Holtec System. The regulators undertook a visit, and discussions were held in regard to interim dry spent fuel storage with Westinghouse, a dry spent fuel store operator for an operating Westinghouse PWR in the US, and the US Nuclear Regulatory Commission (US NRC).

72 We carried out a Joint Regulators visit to Westinghouse at its headquarters in Pittsburgh in July 2008 to discuss its proposals for dry spent fuel storage using the Holtec system. During this visit, we carried out an inspection visit to a Westinghouse PWR, the Joseph M Farley Plant, Alabama, jointly with HSE, to view a dry spent fuel storage installation at an operating nuclear power plant. We held discussions with the operating company, Southern Company to determine its experience in managing spent fuel and operating a dry interim storage facility, and to learn more about the process of preparing the spent fuel for transfer to dry storage.

73 There are a large number of licensed, operating independent spent nuclear fuel storage installations (ISFSIs) in the United States and discussions were held with

the US NRC in regard to its regulation of independent spent fuel installations. In its Step 3 Assessment Report for radioactive waste, HSE cite US NRC findings (HSE, 2009) :

a) ”reasonable assurance that, if necessary, spent fuel generated in any reactor can be stored safely without significant environmental impacts for at least 60 years beyond the licensed life for operation….”

74 DECC considered UK and international experience of managing higher activity waste in developing its preliminary conclusions on new build waste (DECC, 2009c). A range of evidence on the arrangements for the management and disposal of the waste from new nuclear power stations was reviewed and summarised in a paper published by DECC. For example, for interim storage of spent fuel, evidence was reviewed from OECD Nuclear Energy Agency (NEA), and the US NRC. US NRC evidence indicates that spent fuel can be stored safely and securely without significant environmental impact for at least 100 years. Evidence from OECD member countries is that spent fuel has been safely and securely stored for several decades and such storage may continue for many more decades with proper control and supervision, as well as repackaging of some wastes and periodic refurbishment of stores. The NEA also noted that stores of modern design have typically been licensed for periods of decades. The DECC paper also noted that considerable international experience exists for dry fuel stores that give confidence that similar stores can be constructed and licensed for operation in the UK.

75 The HSE has commissioned the National Nuclear Laboratory to carry out work to identify mechanisms that could lead to early failure of the fuel cladding or the fuel assembly during storage. This work will be reviewed in HSE’s Step 4 and the findings will be taken into account in our final decision.

76 Westinghouse has obtained and provided a view from the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA) (as the UK authoritative source) on the disposability of its proposed arisings of spent fuel. Westinghouse provided the regulators with the NDA RWMD GDA Disposability Assessment reports for the AP1000 in October 2009 (summary report), and January 2010 (part 1:main report and part 2:data sheets and inventory tables). Westinghouse provided an opinion of the RWMD assessment reports in October 2009 which they placed on its public website for GDA.

77 RWMD prepared a GDA disposability assessment for the higher activity wastes and spent fuel anticipated to arise during the operational life of an AP1000. Westinghouse provided information on spent fuel expected to arise from an AP1000 operating for 60 years with a maximum fuel assembly average irradiation/burn up of 65 GWd/tU. RWMD conservatively assumed that all spent fuel would achieve this burn up. However, it is more realistic to assume that this represents the maximum of a range of burn up values for individual fuel assemblies.

78 RWMD assume that the spent fuel will be delivered to the disposal facility packaged in robust disposal canisters, made from copper or steel which would contain up to 4 spent fuel assemblies in a cast iron inner vessel. It is also assumed that the spent fuel will be delivered to the GDF packaged in the disposal canisters.

79 RWMD concluded that Westinghouse supplied inventory data sufficient to provide confidence in the conclusions of the GDA disposability assessment. The principal radionuclides in the wastes and spent fuel are the same as those present in existing UK legacy wastes and spent fuel. In particular, to the anticipated arisings from the existing PWR at Sizewell B. The design of the AP1000 and the PWR at Sizewell are similar and it is expected that the operating regimes will be similar.

80 The comparison of AP1000 and Sizewell B spent fuel inventories compared the AP1000 maximum fuel assembly average burn up inventory with the batch average fuel burn up inventory for Sizewell B. RWMD recognised it would have been more appropriate to compare either the two maximum fuel assembly average burn up or

two batch average fuel burn up inventories. The information was not available to do this at the time of the RWMD assessment.

81 RWMD evaluated the implications of constructing a single AP1000 and a fleet of AP1000s. A fleet of 9 AP1000s was chosen to represent a generating capacity of approximately 10GW(e), equivalent to the capacity of the existing nuclear reactors in the UK which will cease to be operational over the next 20 years.

82 The disposability assessment undertaken by RWMD for the AP1000 assumes that 64 fuel assemblies will be generated every 18 months of reactor operation, which, for an assumed 60 year operating life results in a total of 2560 assemblies requiring disposal which is equivalent to 640 canisters.

83 The potential impact of the disposal of AP1000 spent fuel on the size of the geological disposal facility has been assessed. The area required represents approximately 6% of the area required for legacy HLW and spent fuel per AP1000 reactor and approximately 55% for the illustrative fleet of 9 AP1000s. This is in agreement with previous estimates from Nirex (the predecessor organisation to RWMD) for potential new build reactor designs.

84 RWMD undertook an assessment which considered the spent fuel disposal packages against the waste package standards and specifications developed by RWMD and the supporting safety assessments for a geological disposal facility. The safety of transport operations, handling and emplacement at a Geological Disposal Facility, and the longer term performance of the system have been considered, together with the implications for the size and design of the GDF. The potential disposability of spent fuel from the AP1000 was considered with existing assessments of RWMD reference disposal concepts. These assessments provide the basis for judging the potential disposability of AP1000 wastes and spent fuel. One important consideration for the assessment of spent fuel from the AP1000 is that increased burn up and irradiation of the fuel will result in an increased concentration of fission products and higher actinides which causes the fuel assemblies to have a higher thermal output and dose rate.

85 A reference disposal concept is used for the disposability assessment based on the KBS-3V concept developed by SKB for the disposal of spent fuel in Sweden. Spent fuel will be over-packed into durable, corrosion-resistant canisters manufactured from suitable materials that will provide containment for the radionuclides associated with the spent fuel. The assessment has considered the performance of both copper and steel canisters with a cast iron inner vessel used to hold and locate the spent fuel canisters. The canisters would be emplaced in disposal holes lined with a buffer made from compacted bentonite which swells following contact with water.

86 The disposability assessment undertaken by RWMD also considered for spent fuel, estimates of risks from migration of radionuclides to the biosphere following closure of the GDF, with risks considered for the groundwater pathway.

87 In accordance with discussions with Westinghouse, fuel burn-up for an AP1000 is accumulated in an irradiation “history” assumed to consist of four irradiation cycles of 510 days duration and a fifth cycle of 307 days duration, with 17 days shutdown interval, with the reactor shutdown for maintenance purposes.

88 RWMD concluded that compared with legacy waste and existing spent fuel, no new issues arise that challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of the AP1000.

89 The disposal route for rod cluster control assemblies, RCCAs will need to be clarified. The RWMD assessment indicates that they will not represent a major addition to the overall inventory, and that they could be conditioned separately as ILW or disposed of with the rest of the fuel assembly.

90 The regulators required further information from Westinghouse in TQ-AP1000-232 on the volume and radionuclides/activity for waste, including rod cluster control assemblies, RCCAs, redundant irradiated control rods, neutron source assembly and poison rod assemblies, including evidence that they will be disposable. Westinghouse identified rod cluster control assemblies, RCCAs include 53 assemblies which are replaced once every 20 years. Similarly, there are also 16 grey rod assemblies, which are replaced every 20 years when they become redundant. Both the RCCAs and grey rod assemblies are disposed within the spent fuel assemblies. There are 72 poison rod assemblies that are used in the first core only and then disposed of as waste. There are two primary and two secondary neutron source assemblies. The primary sources are used once during the first cycle then disposed of and the secondary source assemblies are replaced once every 20 years. Westinghouse proposes all for disposal with the spent fuel.

91 Westinghouse provided the regulators with an opinion of the RWMD disposability assessment, and this is available on its website. The regulators requested further information from Westinghouse including a more detailed critique of those issues raised by RWMD in its disposability assessment, considering the impact on its plans for conditioning, storing and dispatching the waste to a repository (GDF).

92 Our assessment report on disposability of ILW and Spent Fuel (Environment Agency, 2010c) considers both Westinghouse's opinion and the RWMD assessment. It concludes that subject to a satisfactory demonstration that spent fuel 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 spent fuel will not be disposable in a suitably designed and located GDF. Please refer to this report for more information.

93 The regulators requested information from Westinghouse in TQ-AP1000-329 on encapsulation of the spent fuel since this was not considered by the RWMD assessment. Westinghouse responded with information, including an outline of the current option for encapsulation of AP1000 spent fuel for dry storage; a description of the spent fuel repackaging system as a way of demonstrating that the necessary technology exists for encapsulating fuel for the GDF; and information relating to the GDF proposed for Sweden which incorporates features expected for the UK GDF. Section 10 of the radioactive waste management case (RWMC) evidence report for HLW outlines the proposed conditioning and disposability options for spent fuel.

94 The current option for encapsulation of spent fuel for dry storage is presented in the ER section 3.5.9.3 High Level Waste. The dry fuel would be stored in the multi purpose canister MPC, and it may be necessary to encapsulate the spent fuel from the MPC into the preferred canister for the GDF. The GDF requirements for UK are not finalised; however Westinghouse have considered the Pollux cask currently in use in Germany as the final disposal cask as part of the pilot encapsulation plant that has been operating for over 10 years in Gorleben. Casks for Storage and Transport of Radioactive material, CASTOR flasks are used for interim storage in Germany where spent fuel is repackaged into Pollux casks for final disposal. Information is provided on the encapsulation processes based on the Pollux system. The fuel element conditioning can be done on site or at a centralised facility. It may be possible for spent fuel to be placed in a RWMC disposal canister, once it has been removed from the cooling pool.

95 In order to demonstrate that encapsulation of spent fuel from UK AP1000 is achievable and safe, Westinghouse considered information related to the GDF proposed for Sweden, where the location and design of the GDF has been determined. The proposal is for spent fuel is to be encapsulated in copper canisters which are then embedded in Bentonite clay at a depth of 500m in the crystalline bedrock of the GDF. The canister, bentonite and bedrock provide three separate barriers and prevent contamination from the spent fuel from reaching the

groundwater. The encapsulation canister is similar to one proposed by NDA in the RWMD assessment.

96 The regulators asked Westinghouse to provide information on the potential actinide content of solid, liquid and gaseous wastes arising from reasonably foreseeable events during the lifecycle of the AP1000 in TQ-AP1000-211. This included the potential for the fuel to contain tramp uranium, that is traces of uranium on the outside of the cladding left over from manufacture of the fuel, and potentially for fuel failure to occur.

97 Westinghouse responded that actinide release to a waste stream is possible if there is a leak in one or more fuel rods. Westinghouse provided information to support low leakage rates from fuel rods for the robust fuel assembly type fuel. The AP1000 fuel design for UK is based on this robust fuel assembly, RFA fuel, which is an improvement on previous fuel designs in that vibrations in the assembly are reduced. Westinghouse claim that given the low leak rate from fuel rods there should be little actinide activity in the Reactor Coolant System (RCS).

98 Westinghouse provided information from its fuel manufacturing operations in the US. The smear monitoring carried out on the fuel rods confirmed that tramp uranium contamination is insignificant.

99 Fuel assemblies are claimed to be of a robust design and evidence was provided as detailed above for the estimated fuel failure rate. The submission indicates that data is based on 0.25% fuel defects which is a conservative estimate. The IWS provides information on the fuel performance based on international operating experience. The IWS provides information on the robust fuel assembly type fuel (RFA), and details of the fuel operational regime.

100 Plans for dealing with defective fuel are included in Westinghouse's Integrated Waste Strategy, IWS. There are five individual defective fuel assembly storage cells in the spent fuel pool. The evidence report for HLW also discusses segregation of HLW with regard to segregation of defective fuel assemblies from non-defective assemblies in the fuel pool.

101 The regulators requested further information from Westinghouse in regard to disposability of spent fuel and ILW in RO-AP1000-60. With particular regard to Westinghouse's review of the RWMD disposability assessment, the regulators needed more detail from Westinghouse when considering the impact of the RWMD review on its plans for conditioning, storing and dispatching the waste to a repository (GDF). Westinghouse were asked to make a case for the disposability of spent fuel and ILW to ensure it can be stored, transported and disposed of. The case should include consideration of the issues identified in the RWMD disposability assessment, and a detailed Westinghouse' critique of the RWMD assessment, and should include a plan showing how and when the issues will be addressed. A response was received from Westinghouse in late February 2010. This response was considered in our assessment report on Disposability of ILW and Spent Fuel (Environment Agency, 2010c) which found the plans proposed to address outstanding disposability issues to be adequate at this stage. Please refer to this report for further information.

102 The Regulators required the Requesting Parties for GDA to provide information to demonstrate the facility for long term interim storage of spent fuel can be designed for the total expected lifetime. Long term interim storage is required until a Geological Disposal Facility is available for direct disposal of spent fuel. The long term provision of services, for example to a storage pool for spent fuel, after a reactor has been shut down is required to be considered. A paper was issued in GDA "The required level of design of waste plants for new build reactors in the Generic Design Assessment." (HSE, 2009). The paper sets out requirements for a Requesting Party to provide sufficient levels of design to justify credibility of the proposed storage options; understanding how waste streams and their packaging

evolve during the storage period, the need for data and records management, knowledge of the constraints placed on the wastes by the disposal facility, identification of knowledge gaps and a supporting research programme to address the gaps, and robust estimates of the required capacity.

103 A Regulatory Observation was issued to Westinghouse in draft in early March 2010 following a discussion with HSE in regard to long term storage. This was issued formally in April 2010 as RO-AP1000-74. The regulatory observation requested further information on long term storage. The actions associated with the RO outline the requirement for a plan showing when facilities for long term storage should be operational, and the research needed to underpin these plans to ensure that spent fuel can be stored transported and disposed of. Other actions required Westinghouse to show how they will manage records over the lifecycle of the waste, to show how human factors have been built into longer term waste management plans and to show how facilities will be maintained over an extended storage period.

104 HSE wrote to us in March 2010 in regard to its step 4 assessment, including those aspects that could affect disposability of spent fuel. Regulatory observations have been raised by the regulators on long term storage and disposability of spent fuel as discussed in the preceding paragraphs. HSE, in its Step 4 of GDA ,will continue to review the information supplied by Westinghouse as they finalise the information contained in its submissions on long-term storage and disposability. We will continue to work closely with HSE on these issues and this work will inform our decision document.

3.8 BAT to minimise disposals of spent fuel

105 Information is provided in the BAT report, including the radionuclide BAT forms provided by Westinghouse, on the measures Westinghouse have incorporated in the design and use of fuel materials, and reactor controls to minimise emissions at source.

106 The Westinghouse BAT assessment report does not address HLW, namely spent fuel, in detail and refers out to the ER section 3.5.4.3. The BAT report includes information on zinc addition to reduce corrosion product transport to the fuel. There is also information on fuel rod burn up, operational cycle, and fuel rod cladding design in regard to minimising emissions at source.

107 The development of the AP1000 design over a 15 year period, including the predecessor AP600 design, involved a number of design decisions that relate to minimising waste and applying best available techniques, BAT.

108 One of these decisions was using zinc addition to reduce the potential for corrosion product transport to the fuel. The AP1000 design includes a chemical and volume control system (CVCS) that incorporates a zinc addition sub-system to reduce the rate of corrosion and the release of corrosion products in the RCS, which has the potential to cause primary side stress corrosion cracking and crud induced power shift. Zinc addition also reduces the potential release of active corrosion products into the liquid radwaste system. The other benefit of zinc addition is the potential to reduce occupational radiation exposure. We note HSE has raised some concern about reliance on Zn for fuel protection.

109 The BAT decisions for the longer term interim fuel storage were based on whether to store the fuel wet or dry, also whether to store the fuel above or below ground. Fuel transfers are all carried out underwater. For longer term storage of the fuel in canisters, Westinghouse notes it is preferable to store fuel under an inert gas atmosphere to minimise the corrosion issues associated with long-term wet storage.

110 Westinghouse claims that underground storage has the advantage of providing greater levels of shielding and a more secure solution with respect to the potential for aircraft impact and other catastrophic events. The disadvantages relate to control of groundwater issues and flood risk. Westinghouse notes these issues will need to be considered at the site-specific design stage.

111 For the generic site, Westinghouse proposes a dry spent fuel storage system to be stored inside an underground cylindrical cavity.

112 Westinghouse has not provided information on any discharges from spent fuel storage. We would not expect discharges from interim spent fuel storage to be significant, and unless evidence is provided by Westinghouse to the contrary, we propose any discharges would be within the limits and levels proposed in Chapters 9 and 10 of our consultation document (Environment Agency 2010b).

4 Public comments

113 We addressed comments we received on spent fuel from the public involvement process relating to the AP1000 design by 4 January 2008 in our preliminary assessment report (Environment Agency, 2008). Public comments on this subject were received during our detailed assessment stage. One comment requested information about the type of spent fuel cask that would be used to transport spent fuel for processing or disposal. Westinghouse's response was that the exact model of the spent fuel cask to transport spent fuel for processing or disposal has not yet been chosen. It is stated, however, that the cask selected will meet the requirements of IAEA and UK standards for design and construction. The cask chosen will have been shown to survive a sequence of four simulated accident conditions involving impact, puncture, fire and submersion in water. Both during and after the tests, the cask must contain the nuclear material, limit radiation doses to acceptable levels, and prevent a nuclear reaction.

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5 Conclusion

114 We conclude that in its submission, Westinghouse describes how spent fuel will arise, be managed and disposed of throughout the facility's lifecycle. Westinghouse provides information on new fuel composition and characteristics, and proposed fuel burn up. Westinghouse considered operating strategies in regard to spent fuel generation, and quantities of spent fuel that will arise. Information is provided in the submission and supporting documents on short and long-term management proposals for spent fuel. The strategy proposed by Westinghouse for managing spent fuel following its removal from the reactor, is to transfer the spent fuel to the spent fuel pool for storage and initial cooling for a period of around 18 years. The fuel is then proposed to be transferred to a dry interim storage facility until such time a geological disposal facility becomes available for direct disposal.

115 The strategy is consistent with our REP, RSMDP1 Radioactive Substances Strategy. The evidence provided for BAT for the AP1000 fuel design and to minimise disposals satisfies RSMDP3 use of BAT to minimise waste. Information will be provided on record keeping, together with further information on longer term storage. This will be assessed and considered in our decision document for compliance with our REPs, in particular RSMDP14 record keeping, and RSMDP10 storage.

116 Westinghouse has obtained a view from NDA RWMD on the disposability of the fuel and has provided its opinion to the regulators.

117 Westinghouse's proposals for storage of spent fuel are based on current practice. Westinghouse states confidence in managing long-term storage on the basis of international experience gained in spent fuel storage, and on the development of dry storage systems where the spent fuel is kept in an inert sealed atmosphere. The regulators have requested further information about the proposed storage facilities to support the long-term safe storage of the spent fuel and to ensure the fuel does not degrade over the long storage period.

118 Westinghouse provided detailed responses in regard to disposability in March 2010. As noted above the regulators have asked for information in regard to long term storage. HSE is reviewing this information in their Step 4 assessment. We will continue to work with HSE on these matters, and this work will inform our decision document.

119 We need more information on the longer term storage of the fuel to understand whether there is any potential for degradation of the fuel over the longer term that might affect its disposability. This is consistent with the HSE requirement for a satisfactory demonstration that spent fuel can be stored safely for the necessary period of time without significant degradation. This information will be provided as noted above and HSE will review this information in its Step 4 assessment. We will continue to work with HSE on these issues, and this work will inform our decision document. Therefore, our conclusion is subject to the potential GDA Issue:

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

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Abbreviations

ALARP	As Low As Reasonably Practicable
BAT	Best available techniques
CASTOR	Casks for Storage and Transport of Radioactive material
CVCS	Chemical Volume and Control System
DCD	Design Control Document
DECC	Department of Energy and Climate Change
EPRI	Electrical Power Research Institute – an independent USA organisation
ER	Environment Report
FHM	Fuel Handling Machine
GDA	Generic design assessment
GDF	Geological Disposal Facility
HLW	High Level Radioactive Waste (e.g. Spent Nuclear Fuel)
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
ISFSI	Independent Spent Nuclear Fuel Storage Installation
IWS	Integrated Waste Strategy
JPO	Joint Programme Office
MPC	Multi purpose canister
NDA	Nuclear Decommissioning Authority
NEA	Nuclear Energy Agency (of the OECD)
OECD	Organisation for Economic Cooperation and Development
P&ID	Process and information document
PCSR	Pre-Construction Safety Report
PWR	Pressurised water reactor
QA	Quality Assurance
RCCAs	Rod cluster control assembles
RCS	Reactor Coolant System
REPs	Radioactive substances environmental principles
RFA	Robust Fuel Assembly
RGN	Regulatory Guidance Note
RGS	Regulatory Guidance Series
RO	Regulatory Observation
RWMC	Radioactive Waste Management Case
RWMD	Radioactive Waste Management Directorate of the Nuclear Decommissioning Authority
SNF	Spent nuclear fuel. That is fuel that has been irradiated in and permanently removed from a reactor core (IAEA)

SODA	Statement of Design Acceptability
TQ	Technical Query
US NRC	United States Nuclear Regulatory Commission
VVM	Vertical Ventilated Module
WEC	Westinghouse Electric Company LLC

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