Office for Nuclear Regulation

An agency of HSE

Generic Design Assessment – New Civil Reactor Build

GDA Close-out for the EDF and AREVA UK EP™ Reactor
GDA Issue GI-UKEPR-RP-01 Revision 0 – Radiological Zoning and Bulk Shielding

Assessment Report: ONR-GDA-AR-12-007
Revision 0
December 2012

COPYRIGHT

First published December 2012

EXECUTIVE SUMMARY

This report presents the close-out of the Office for Nuclear Regulation's (an agency of HSE) Generic Design Assessment (GDA) for the GDA Issue **GI-UKEPR-RP-01** Revision 0 and the associated GDA Issue Action generated as a result of the GDA Step 4 Radiological Protection Assessment of the UK EPR™. The assessment has focussed on the deliverables identified within the EDF and AREVA Resolution Plan published in response to the GDA Issue.

The view of the Office for Nuclear Regulation (ONR), an agency of HSE, is that radiological zoning for restriction of exposure to ionising radiations of workers is fundamental to the basic design of the UK EPR™. In addition, bulk shielding is inextricably linked with civil engineering aspects of the UK EPR™, and bulk shielding assessments need to be completed before nuclear island construction commences. Therefore, ONR considers that suitable and sufficient detailed work should be completed within GDA to demonstrate that the bulk shielding provided by nuclear island construction concrete is adequate.

The radiological zoning classification scheme was not referenced in the GDA submission for Step 4 of the UK EPR™ design. The objective of the GDA Issue was for EDF and AREVA to provide a radiological zoning classification scheme and predicted dose rates taken from shielding assessments to demonstrate that there was adequate shielding provision for all areas of the facility.

In response to the GDA Issue, EDF and AREVA provided an overview document that provided information / documentation which summarised the dose rates and radiological classifications within all rooms and for all modes of plant operation (for example, power operation, outages, refuelling). The overview document summarised the results of shielding calculations to show that the predicted dose rates within each area met the radiological classification. The overview document was referenced in the updated consolidated PCSR.

From my assessment, I have concluded that the shielding provisions for the radiological zoning of the facility have been designed to ensure that exposures to workers and members of the public to ionising radiation have been restricted so far as is reasonably practicable during all modes of plant operation.

ONR will in future need some additional detailed information to underpin my conclusions, but it is not appropriate to progress this at the current stage of design development. This has therefore been identified as an Assessment Finding on the topic of the provision of adequate engineering or administrative measures to restrict access of personnel to the fuel loading hall in the Fuel Building during fuel handling operations, and to rooms with dual classification in the Nuclear Auxiliary Building during periods when high dose rates are present.

Overall, based on the sample undertaken in accordance with ONR procedures, I am satisfied that the additional information / documentation submitted to close-out the GDA Issue, which supports the claims, arguments and evidence already laid down within the PCSR and supporting documentation during Step 4 of the GDA process, present an adequate safety case for the generic UK EPR™ reactor design.

LIST OF ABBREVIATIONS

ACOP	Approved Code of Practice
ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
CMF	Change Modification Form
EDF and AREVA	Electricité de France SA and AREVA NP SAS
EPR10	Environmental Permitting Regulations 2010
EVU*	Containment Heat Removal System
GDA	Generic Design Assessment
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
IRR99	Ionising Radiations Regulations 1999
NEA	Nuclear Energy Agency
NPP	Nuclear Power Plant
NT	Nuclear Technologies
OECD	Organisation for Economic Co-operation and Development.
ONR	Office for Nuclear Regulation (an agency of HSE)
PCSR	Pre-construction Safety Report
PTR*	Fuel Pool Cooling and Purification System
RCV*	Chemical and Volume Control System
REN*	Nuclear Sampling System
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations 2001
RIS*	Medium Head Safety Injection
RPE*	Nuclear Island Vent and Drain System
SAP	Safety Assessment Principle(s) (HSE)
SED*	Demineralised Water Distribution System
SF	Spent Fuel
SFAIRP	So Far As Is Reasonably Practicable
SG	Steam Generator
TAG	Technical Assessment Guide(s) (ONR)
TEG*	Gaseous Waste Processing System
TEP*	Coolant Storage and Treatment System
TQ	Technical Query
TSC	Technical Support Contractor

LIST OF ABBREVIATIONS

TUV SUD	TÜV SÜD Industrie Service GmbH
WENRA	Western European Nuclear Regulators' Association

* French abbreviation

TABLE OF CONTENTS

Tables

Annexes

1 INTRODUCTION

1.1 Background

1 This report presents the close-out of the Office for Nuclear Regulation's (an agency of HSE) Generic Design Assessment (GDA) within the area of radiological protection. The report specifically addresses the GDA Issue GI-UKEPR-RP-01 Revision 0 and associated GDA Issue Action on radiological zoning and bulk shielding (Ref. 6) generated as a result of the GDA Step 4 Radiological Protection Assessment of the UK EPR™ (Ref. 7). The assessment has focussed on the deliverables identified within the EDF and AREVA Resolution Plan (Ref. 8) published in response to the GDA Issue.

2 GDA followed a step-wise approach in a claims-argument-evidence hierarchy. In Step 2 the claims made by EDF and AREVA were examined and in Step 3 the arguments that underpin those claims were examined. The Step 4 assessment reviewed the safety aspects of the UK EPR™ reactor in greater detail by examining the evidence supporting the claims and arguments made in the safety documentation.

3 From my Step 4 Radiological Protection Assessment, I concluded that the plant and its operations had been designed to ensure that engineered features would restrict exposures to workers and the public to ionising radiation so far as is reasonably practicable during normal operation and accident conditions (Ref. 7). The Step 4 Radiological Protection Assessment also identified a GDA Issue and Assessment Findings as part of the assessment of the evidence associated with the UK EPR™ reactor design (Ref. 7). A GDA Issue is an observation of particular significance that requires resolution before the Office for Nuclear Regulation (ONR), an agency of HSE, would agree to the commencement of nuclear safety related construction of the UK EPR™ within the UK. Assessment Findings result from a lack of detailed information and they identify the information that will be required to underpin the safety case and they are carried forward as part of normal regulatory business.

4 The Step 4 Assessment concluded that the UK EPR™ reactor was suitable for construction in the UK subject to resolution of 31 GDA Issues across a range of technical areas. One of those areas was radiological protection and the purpose of this report is to provide the assessment which underpins the judgement made in closing GDA Issue GI-UKEPR-RP-01.

1.2 Scope

5 This Assessment Report presents only the assessment undertaken as part of the resolution of the GDA Issue and it is recommended that this Report be read in conjunction with the Step 4 Radiological Protection Assessment of the EDF and AREVA UK EPR™ (Ref. 7) in order to appreciate the totality of the assessment of the evidence undertaken as part of the GDA process. This Assessment Report is not intended to revisit aspects of assessment already undertaken and confirmed as being adequate during previous stages of GDA.

6 The possibility of further Assessment Findings arising on this topic is not precluded given that resolution of the GDA Issue may identify where further detailed evidence should be provided when the information becomes available at a later stage of design development.

7 ONR's view is that a radiological zoning scheme is an essential tool in defining radiological protection measures (e.g. shielding provisions, ventilation) to restrict exposures to ionising radiation of workers and is fundamental to the basic design of the UK EPR™. In addition, bulk shielding is inextricably linked with civil engineering aspects

of the UK EPR™, and bulk shielding assessments need to be completed before nuclear island construction commences. Therefore, ONR considers that suitable and sufficient detailed work should be completed within GDA to demonstrate that the bulk shielding provided by nuclear island construction concrete is adequate.

8 The background to the GDA Issue on radiological zoning and bulk shielding is that the evidence presented in the Pre-construction Safety Report (PCSR) (Refs 11 and 12) to justify the adequacy of the shielding included in the generic design was not sufficient. EDF and AREVA had submitted methodologies of radiation protection studies and radiation protection guidelines, and had provided samples of calculations in the Reactor Building and Fuel Building. However, the arguments presented in Sub-chapter 12.3 of the PCSR (Refs 11 and 12) needed be substantiated by additional information.

9 EDF and AREVA were unable to provide this information / documentation within the timescale of Step 4 of the GDA assessment because it took a period of time for ONR and EDF and AREVA to come to a common understanding on the evidence required.

10 The GDA Issue Action GI-UKEPR-RP-01.A1 to GDA Issue GI-UKEPR-RP-01 requires EDF and AREVA to provide an overview radiological zoning document that provides evidence to support the claims and arguments made in the PCSR (Refs 11 and 12). The overview radiological zoning document should summarise the results of shielding calculations and show that the predicted dose rates within each area of the plant meet the radiological classification.

11 ONR has a sampling approach for its assessment work, and that sampling process has to be based upon a sampling strategy. In this case, the sampling strategy was to review the high level radiological zoning classification scheme through the submission made in response to GI-UKEPR-RP-01, and then to choose samples from that scheme for ONR's shielding assessments.

1.3 Methodology

12 The methodology applied to this assessment is identical to the approach taken during Step 4 which followed the ONR HOW2 process (formerly the Business Management System) (Ref. 1), in relation to mechanics of assessment within ONR.

13 This assessment has been focussed primarily on the submissions relating to resolution of the GDA Issue as well as any further requests for information or justification derived from assessment of those specific deliverables.

14 The aim was to undertake a comprehensive assessment of the submissions provided in response to GDA Issue GI-UKEPR-RP-01 to enable ONR to gain confidence that the concerns raised have been resolved sufficiently so that they can either be closed or lesser safety significant aspects be carried forward as Assessment Findings.

1.4 Structure

15 This Assessment Report differs slightly from the structure adopted for the previous reports produced within GDA, most notably the Step 4 Radiological Protection Assessment (Ref. 7), as it has been structured to reflect only the assessment of the GDA Issue associated with this technical area.

16 The reasoning behind adopting this report structure is to allow closure of GDA Issues as the work is completed rather than having to wait for the completion of all the GDA work across the range of technical areas.

2 ONR'S ASSESSMENT STRATEGY FOR RADIOLOGICAL PROTECTION

17 The intended assessment strategy for GDA close-out for the radiological protection topic area was set out in an assessment plan that identified the intended scope of the assessment and the standards and criteria that would be applied (Ref. 17).

18 The overall bases for the assessment of the GDA Issue are the radiological protection elements of:

- Submissions made to ONR in accordance with the Resolution Plan (Ref. 8).
- Update to the Submission / PCSR / Supporting Documentation.
- The Design Reference that relates to the Submission / PCSR as set out in UK EPR™ GDA Project Instruction UKEPR-I-002 (Ref. 9) which will be updated throughout GDA Issue resolution. This includes Change Management Forms (CMF), for any design changes agreed for inclusion within GDA.
- Design Change Submissions – which are proposed by EDF and AREVA and submitted in accordance with UK-EPR GDA Project Instruction UKEPR-I-003 (Ref. 10).

2.1 The Approach to Assessment for GDA Close-out

19 The approach to the closure of the GDA Issues for the UK EPR™ Project involves assessment of submissions made by EDF and AREVA in response to the GDA Issue identified through the GDA process. These submissions are detailed within the EDF and AREVA Resolution Plans for each of the GDA Issues. In the event of requiring further supporting evidence for the assessment, Technical Queries (TQ) are generated, which may be supplemented by formal letters where necessary.

20 The objective of the radiological protection assessment has been to assess submissions made by EDF and AREVA in response to the GDA Issue identified through the GDA process and the design changes requested by EDF and AREVA and, if judged acceptable, clear the GDA Issue.

2.2 Standards and Criteria

21 The key pieces of legislation on the protection of workers and members of the public are the Ionising Radiations Regulations 1999 (IRR99) (Ref. 24), Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR) (Ref. 25) and Environmental Permitting Regulations 2010 (EPR10) (Ref. 26). The key pieces of associated guidance are the Approved Code of Practice (ACOP) and guidance to IRR99 (Ref. 27) and guidance to REPPIR (Ref. 28).

22 In addition to legislation and its associated guidance, the relevant standards and criteria adopted within this assessment are principally the Safety Assessment Principles (SAP) (Ref. 2), internal ONR Technical Assessment Guides (TAG) (Ref. 3), relevant national and international standards (Refs 4, 5 and 23) and relevant good practice informed from existing practices adopted on nuclear licensed sites in the UK and abroad. The key SAPs (Ref. 2) and relevant TAGs (Ref. 3) have been identified in Sections 2.2.1 and 2.2.2, respectively. National and international standards and guidance have been referenced where appropriate within this Assessment Report and have been identified in Section 2.2.3. Relevant good practice, where applicable, has also been cited within the body of the assessment.

2.2.1 Safety Assessment Principles

23 The key SAPs (Ref. 2) applied within the radiological protection assessment of the EDF and AREVA UK EPR™ are RP.3 (Radiation Protection: Designated Areas) and RP.6 (Radiation Protection: Shielding), and are included in Table 1 of this report.

2.2.2 Technical Assessment Guides

24 The following TAGs have been used as part of this assessment (Ref. 3).

- T/AST/002 Issue 3. ONR Technical Assessment Guide – Radiation Shielding. HSE. March 2009.
- T/AST/038 Issue 2. ONR Technical Assessment Guide – Radiological Protection. HSE. June 2009.

2.2.3 National and International Standards and Guidance

25 The following international standards and guidance have been used as part of this assessment (Refs 4, 5 and 23).

- Western European Nuclear Regulators' Association (WENRA). Reactor Harmonization Group. WENRA Reactor Reference Safety Levels. WENRA. January 2008 (Ref. 4).
- Safety of Nuclear Power Plants: Design. Safety Requirements. Safety Standards Series No. NS-R-1. International Atomic Energy Agency (IAEA). 2000 (Ref. 5).
- Radiation Protection Aspects of Design for Nuclear Power Plants. Safety Guide No. NS-G-1.13. International Atomic Energy Agency (IAEA). 2005 (Ref. 5).
- Occupational Radiological Protection Principles and Criteria for designing New Nuclear Power Plants. NEA No. 6975. Nuclear Energy Agency (NEA): Organisation for Economic Co-operation and Development (OECD). 2010 (Ref. 23).

26 The WENRA and IAEA standards and guidance (Refs 4 and 5, respectively) are both relevant to SAPs RP.3 on Designated Areas and RP.6 on Radiation Shielding. The NEA: OECD guidance (Ref. 23) provides data on collective doses for advanced pressurised water reactors which are due in part to shielding provisions, and includes the new EPR as a case study.

2.3 Use of Technical Support Contractors

27 Technical Support Contractors (TSC) were engaged to assist with the radiological protection and shielding assessment work during the close-out of GDA and are summarised below.

- Nuclear Technologies (NT) undertook a detailed technical review of shielding (Ref. 18).
- NT / TÜV SÜD Industrie Service GmbH (TUV SUD) undertook a detailed technical review of radiological protection (Ref. 19).

28 Whilst the TSCs undertook detailed technical reviews, these reviews were under close direction and supervision by ONR, and the regulatory judgments on the adequacy or otherwise of the radiological protection aspects of the UK EPR™ were made exclusively by ONR. The findings relating to radiological protection aspects of the technical reviews by TSCs are incorporated into Section 4 of my report, as appropriate.

29 The visibility of TSC work and feedback on progress and outcomes of TSC work was provided to EDF and AREVA throughout the process.

2.4 Out-of-scope Items

30 There were no out-of-scope items relating to GI-UKEPR-RP-01.

3 EDF AND AREVA DELIVERABLES IN RESPONSE TO THE GDA ISSUE

31 The information provided by EDF and AREVA in response to this GDA Issue, as detailed within their Resolution Plan (Ref. 8), was broken down into one component GDA Issue Action and then further broken down into specific deliverables for detailed assessment.

GDA Issue Action	Radiological Protection	Deliverable	Ref.
GI-UKEPR-RP-01.A1	Provide an overview document that supplements the claims and arguments presented in the PCSR Chapter 12.3 with additional information on the radiological zoning classification scheme for the nuclear island, including dose rate criteria and predictions for all modes of plant operation, for occupied areas as a direct reference from the PCSR.	Overview document presenting the radiological protection zoning of the EPR nuclear island (Reactor Building, Fuel Building, Safeguard Buildings and Auxiliary Building).	20
		Responses to TQs relating to the overview document.	16
		Update of the overview document.	21
		Update of PCSR Sub-Chapter 12.3 “Radiation Protection Measures” (Revision 04 of UKEPR-0002-123).	22

32 An overview of each of the deliverables is provided within Sections 3.1 to 3.4. It is important to note that this information is supplementary to the information provided within the November 2009 and March 2011 PCSR (Refs 11 and 12) which have already been subject to assessment during earlier stages of GDA. In addition, it is important to note that the deliverables are not intended to provide the complete safety case for radiological protection. Rather they form further detailed arguments and evidence to supplement those already provided during earlier Steps within the GDA Process.

3.1 1st Deliverable

33 The 1st deliverable (Ref. 20) was the overview radiological zoning document that presented the radiation protection zoning of the UK EPR™ nuclear island for the Reactor Building, Fuel Building, Nuclear Auxiliary Building and Safeguard Buildings. This overview radiological zoning document included the following information.

- Room descriptor and number / designation.
- Radiological classification (namely dose rate criteria).
- Dose rate prediction(s) for each room giving the maximum dose rate present during all modes of operation (e.g. power operation, outages, refuelling).
- Reference to shielding assessments / calculations from Flamanville 3 containing data regarding the assumed radiation sources, shielding provisions and calculated dose rates (the Flamanville 3 EPR was the reference design for the UK EPR™).

3.2 2nd Deliverable

34 The 2nd deliverable (Ref. 16) was the response to TQs raised by ONR relating to the Reactor Building, Fuel Building, Nuclear Auxiliary Building and Safeguard Buildings.

3.3 3rd Deliverable

35 The 3rd deliverable (Ref. 21) was the revised version of the overview radiological zoning document which took into account of comments made by ONR on the original version of the document (Ref. 20).

3.4 4th Deliverable

36 The 4th deliverable (Ref. 22) was the updated version of Sub-chapter 12.3 of the PCSR which referred to the revised version of the overview radiological zoning document (Ref. 21).

4 ONR ASSESSMENT

37 Further to the assessment work undertaken during Step 4 (Ref. 7), and the resulting GDA Issue GI-UKEPR-RP-01 (Ref. 6), this Assessment Report focuses on the overview radiological zoning document provided by EDF and AREVA on radiological zoning and bulk shielding in the nuclear island of the UK EPR™ design (Ref. 20). Identified deliverables intended to provide the requisite evidence were provided within the responses contained within the Resolution Plan (Ref. 8) provided by EDF and AREVA at the end of Step 4 of GDA.

38 This assessment has been carried out in accordance with internal ONR guidance on assessment given in How2 document PI/FWD (Ref. 1).

4.1 Scope of Assessment Undertaken

39 The scope of the assessment has been to consider the expectations detailed in the GDA Issue, GI-UKEPR-RP-01, and the associated GDA Issue Action, GI-UKEPR-RP-01.A1 (Ref. 6). These are detailed within Annex 2 of this report. The GDA Issue Action required EDF and AREVA to provide an overview radiological zoning document that supplemented the claims and arguments presented in the PCSR, Sub-Chapter 12.3 (Refs 11 and 12) with additional information on the radiological zoning classification scheme for the nuclear island, including dose rate criteria and predictions for all modes of plant operation for occupied areas as a direct reference from the PCSR. Evidence to be included in the overview radiological zoning document included information / documentation on the Reactor Building, Fuel Building, Nuclear Auxiliary Building and Safeguard Buildings. However, should information have been identified that had an affect on the claims made for other aspects of radiological protection such that the existing case was undermined, these would have been addressed.

4.2 Assessment

4.2.1 Background

40 Assessment of designated areas was outlined in my Step 3 Radiological Protection Assessment Report (Ref. 29). Evidence to demonstrate designated areas was considered during Step 4 (Refs 7 and 30). I was supported in my Step 4 assessment by TSCs, NT and TUV SUD (Refs 31 and 37).

41 IRR99 require appropriate areas to be designated as controlled or supervised areas (Ref. 24). The designation of these areas within a nuclear facility should take account of the level of hazard and risk from exposure to external radiation and / or internal radiation from surface and airborne contamination. Such a designation scheme is usually referred to as a “radiological classification of areas scheme” in the UK, and as a “radiological zoning scheme” in France.

42 The criteria for the classes of the UK EPR™ radiological classification for external radiation are reproduced in Table 2 of this Assessment Report (taken from Ref. 20). In brief, zones were classified as “blue”, “green”, “yellow”, “orange” or “red”. The “blue” zone was a monitored area (a supervised area under IRR99, Ref. 24) and the other zones were controlled areas (under IRR99, Ref. 24), referred to as Regulated Work Areas, Regulated Stay Areas, Limited Stay Areas and Prohibited Areas, respectively. This radiological classification was an evolution of the classification presented in versions of the PCSR assessed during Step 4 (Refs 11 and 12) and new classes had been added above class F (1Svh-1, “red” zone, Prohibited Area, see Table 2) for very high doses (the highest class was now class K with a dose rate of 10,000Svh-1).

43 As the GDA Issue dealt with radiological classification and bulk shielding, the criteria for the classes of the UK EPR™ radiological classification for contamination by radioactivity were not considered in this Assessment Report. My assessment of contaminated areas and ventilation was covered in Sections 4.4 and 4.5, respectively, of my Step 4 Assessment Report (Ref. 7).

44 The objectives of a radiological classification of areas scheme are as follows.

- To ensure compliance with legal requirements.
- To assist in the control of radiation dose uptake (through both external and internal exposure).
- To enable a consistent and efficient plant layout to be developed as a useful basis of design.

45 The radiological classification of areas document is generally considered to be a live document which is revised as required throughout the design and operational phases of the nuclear facility and is developed with advice sought from plant operators, design engineers and radiation protection advisers.

46 In general, the shielding provisions for a proposed nuclear facility are initially based on a preliminary classification of areas scheme which outlines the upper bound dose rates within the scheme for each room of the facility based on the expected occupancy requirements for activities to be undertaken in that room. Where initial dose rate predictions do not meet the criteria, shielding provisions may be revised to further reduce dose rates to within those criteria. Alternatively, in cases where changes to the shielding are not practicable, the radiological zoning classification may be increased to reflect the potential for higher dose rates along with further restrictions on occupancy applied to ensure dose accrual remains ALARP. Shielding summary documents are usually produced to confirm that conservative dose rate predictions acceptably meet the radiological zoning criteria for each room of the facility. This should also include references to the detailed shielding assessments from which the results have been extracted.

47 The view of ONR is that radiological zoning for restriction of exposure to ionising radiation of workers is fundamental to the basic design of the UK EPR™. In addition, bulk shielding is inextricably linked with civil engineering aspects of the UK EPR™, and bulk shielding assessments need to be completed before nuclear island construction commences. Therefore, ONR considers that suitable and sufficient detailed work should be completed within GDA to demonstrate that the bulk shielding provided by nuclear island construction concrete is adequate.

48 The radiological zoning classification scheme was not referenced in the GDA submission for Step 4 of the UK EPR™ design (Refs 7, 11 and 12). The objective of the GDA Issue was for EDF and AREVA to provide a radiological zoning classification scheme and predicted dose rates taken from shielding assessments to demonstrate that there was adequate shielding provision for all areas of the facility.

4.2.2 Overview Radiological Zoning Document

49 In response to the GDA Issue, EDF and AREVA submitted an overview radiological zoning document that provided information / documentation which summarised the dose rates and radiological classifications within all rooms and for all modes of plant operation (e.g. power operation, outrages, refuelling) (Ref. 20). The development of the radiological classification scheme took into account the three-dimensional mock-up of the UK EPR™.

The overview radiological zoning document summarised the results of shielding calculations to show that the predicted dose rates within each area met the radiological classification.

50 My assessment focused on shielding provisions for the radiological zoning of the facility that would restrict exposures to workers and members of the public to ionising radiation so far as is reasonably practicable during all modes of plant operation. I was supported in my assessment by ONR's TSCs, NT (Ref. 18) and TUV SUD (Ref. 19).

4.2.3 TSC Review Plan - Shielding

51 ONR's TSC, NT, undertook the review of the radiological zoning and bulk shielding to consider whether the bulk shielding provisions (e.g. walls, floors and shield doors) had been adequately analysed by EDF and AREVA, as significant changes to these substantial items of shielding could potentially affect the design of the civil structure. In line with the Step 4 GDA shielding review undertaken by NT (Ref. 31), the main objectives of the shielding review were to ensure that the UK EPR™ shielding design fulfils the requirements outlined in UK regulations, and that current guidance and good shielding practices have been implemented when defining the shielding provisions (e.g. SAPs (Ref. 2) and the TAG on Radiation Shielding (T/AST/002) (Ref. 3)).

52 As previously reported during Step 4, the bulk shielding provisions for the Reactor Building will ensure dose rates at the exterior surface of the Reactor Building will be acceptable and provide adequate protection to the public from external radiation (Refs 7 and 31). In addition, the shielding assessment samples for the Reactor Building and Fuel Building (Refs 35 and 36) demonstrated how EDF and AREVA had consistently employed good shielding practices along with appropriate calculation methods during the design and optimisation of the shielding provisions.

53 This additional review considered whether the bulk shielding provisions associated with the civil structure were acceptable. This was achieved through a high level review of the overview radiological zoning document (Ref. 20) and the bulk shielding provisions provided in design layout drawings in response to TQ-EPR-593 during Step 4 (Ref. 13). The findings of this initial review enabled me to raise TQs in consultation with NT to request further information / clarification to allow more detailed investigations into a number of shielding samples for the UK EPR™ shield design.

4.2.4 TSC Review Plan – Radiological Protection

54 ONR's TSC, TUV SUD, reviewed the radiological protection aspects of the UK EPR™ radiological zoning starting with the information provided in the overview radiological zoning document (Ref. 20). UK and international standards were used to review the document.

55 The TSC's review was based on the "ALARP" (as low as reasonably practicable) and "ALARA" (as low as reasonably achievable) principles. In this Assessment Report the UK term "ALARP" is taken to be synonymous with the international term "ALARA" and with the UK legal term "SFAIRP" (so far as is reasonably practicable). These principles are outlined in IRR99 (Ref. 24), HSE's SAPs (Ref. 2) and IAEA Safety Guide on Radiation Protection Aspects of Design for Nuclear Power Plants, NS-G-1.13 (Ref. 5). The purpose of the TSC review was to verify that the requirements of these safety standards and criteria had been incorporated into the design.

56 The IAEA Safety Guide on Radiation Protection Aspects of Design for Nuclear Power Plants, NS-G-1.13 (Ref. 5), provides guidance on optimisation of radiation exposure

within nuclear power plants (NPP) and recommends consideration of the ALARA principle concerning dose rates within NPPs (see Section 4.3.3). One of the key requirements of this IAEA Safety Guide is the concept of design targets which should be set for individual doses and collective doses, especially for groups of workers who are likely to receive the greatest doses of ionising radiation (paragraphs 2.7 and 2.8 in NS-G-1.13) (Ref. 5).

57 Principles reiterating the concepts of ALARP and setting dose constraints in the UK are included in IRR99 (Ref. 24), along with requirements for the designation of controlled areas. The ACOP and guidance to IRR99 (Ref. 27) advise that individual employee doses should not be reduced by sharing amongst a greater number of employees. Rather, the radiation employer should give priority to improving engineering controls and adopting other means of restricting exposure, including changing the methods of work (Ref. 27). However, if a choice has to be made between restricting doses to a group of persons, priority should be given to keeping individual doses as far below dose limits as is reasonably practicable (Ref. 27).

58 The estimated dose rates in the UK EPR™ were compared to dose rates in similar areas within NPPs operating abroad to relevant good practice.

59 TUV SUD initially performed a high level examination of the radiological zoning of the nuclear island (Ref. 20). The findings of this initial review enabled me to raise TQs in consultation with TUV SUD to request further information / clarification to allow more detailed investigations into the radiological profile for the UK EPR™ design.

4.2.5 Methodology for Zoning and Similar Systems

60 This part of my Assessment Report summarises the shielding and radiological protection assessment of topic areas that are relevant to all buildings in the nuclear island, namely the methodologies developed by EDF and AREVA for the radiological zoning scheme and for dealing with similar / symmetrical systems within the nuclear island (e.g. steam generators (SG)).

4.2.5.1 Methodology for Zoning and Similar Systems – Shielding

61 The following Sub-sections 4.2.5.1.1 and 4.2.5.1.2 summarise the assessment and findings of the shielding review for the methodologies for the radiological zoning scheme and for dealing with similar / symmetrical systems within the nuclear island, respectively.

62 Expectations on shielding are in RP.6 of the SAPs (Ref. 2) and in the TAG on Radiation Shielding (T/AST/002) (Ref. 3) (see Section 4.3.2).

4.2.5.1.1 Methodology for the Radiological Zoning Scheme – Shielding Assessment

63 In line with guidance in IRR99 (Ref. 24), the radiation protection guidelines (Ref. 32) presented a scheme for the designation of areas within the nuclear island according to the level of hazard from external radiation and / or the potential for surface and airborne contamination.

64 The overview radiological zoning document (Reference 20) provided a summary of the methodology used to develop the radiation zoning scheme for areas within the UK EPR™ nuclear island. The report included tables outlining the radiological zoning classifications for each area based on calculated dose rates taken from shielding assessments. Where appropriate, some areas had been assigned dual classifications to take into account

changes in dose rates during various modes of operation (e.g. power operation, outage, refuelling).

65 During the review of the overview radiological zoning document, I raised TQ-EPR-1498 (Ref. 16) to request further clarification regarding the methodology used to develop the radiological zoning scheme for the UK EPR™. The response to the TQ from EDF and AREVA provided evidence on the main methodologies for establishing the radiological zoning of the nuclear island which included the following.

- Accessibility requirements were established which took account of expected maintenance requirements and experience feedback, and these identified the maximum dose rates required for all parts of the plant. Once accessibility requirements had been established, requirements for shielding provisions were identified.
- Dose rate calculations were then performed to check whether initial accessibility requirements were achievable based on the preliminary civil works and layout design (extracted from the three-dimensional mock-up of the UK EPR™), and the controlled area was zoned according to a range of dose rates. If the initial accessibility requirements were not achievable, then the need for additional shielding provisions (e.g. concrete maze, steel plate, neutron protection) were identified to enable the accessibility requirements to be achieved.
- For a room which did not contain any sources, dose rates coming from adjacent rooms were calculated to define the final classification. When access was permanently required (and occupancy was often of short duration, such as access corridors), a maximum target dose rate of 25 microSvh^{-1} was set for shielding calculations.
- For a room which contained multiple radioactive sources, several calculation steps were performed. Workers were assumed to be 0.5 metres from any equipment (e.g. piping, components, valves) and the dose rate classification for that room was based on dose rates from all such equipment.
- This classification was then refined as necessary by taking account of dose rates coming from adjacent rooms.

Findings

66 In the opinion of the TSC, from the evidence provided, the approach described by EDF and AREVA was consistent with guidance on IRR99 (Ref. 27) and the methodologies typically employed in the UK (see Section 4.2.1) to identify areas where bulk shielding could be required to isolate sources of radiation and ensure dose rates in adjacent rooms / areas were acceptable (Ref. 18). This iterative approach used to develop the radiological zoning scheme and shielding provisions to attenuate external radiation was consistent with good UK and international practice. I concur with the opinion of the TSC from the evidence provided on the methodology for the radiological zoning scheme.

4.2.5.1.2 Dose Rates for Similar Systems – Shielding

Assessment

67 During the review of the overview radiological zoning document (Ref. 20), it was noted that there were differences in dose rates for similar systems (e.g. differences in dose rates during shutdown conditions between the four SG loops 1-4). TQ-EPR-1498 (Ref. 16) requested further clarification regarding such dose rates for similar systems. The

response to the TQ from EDF and AREVA provided evidence on dose rates for similar systems and included the following.

- The Reactor Building had a great deal of symmetry between its four primary loops. This symmetry meant that it was only necessary to model and calculate dose rates for one loop so long as civil works, layout and equipment designs were similar from one loop to another.
- The tables in the overview radiological zoning document (for both outage and operation at power) gave the actual results of dose rate calculations for one room but these results were not used for dose rates for the other symmetrical rooms. Instead, the upper boundary of the dose rate range was used for these other symmetrical rooms to demonstrate that the dose rate calculations were not performed in these particular rooms. The response to the TQ provided an example to illustrate this point.

Findings

68 In the opinion of the TSC, from the evidence provided, specific shielding calculations had been performed for a system and the dose rates for similar / symmetrical systems were conservatively assigned the upper bound dose rate for the radiological zone and this approach was consistent with relevant good UK and international practice (Ref. 18). I concur with the opinion of the TSC from the evidence provided on the dose rates for similar systems.

4.2.5.2 Methodology for Zoning and Similar Systems - Radiological Protection

69 The following Sub-sections 4.2.5.2.1 and 4.2.5.2.2 summarise the assessment and findings of the radiological protection review for the methodologies for the radiological zoning scheme and for dealing with similar / symmetrical systems within the nuclear island, respectively.

70 Expectations on radiological protection and designation of areas are in RP.3 of the SAPs (Ref. 2), in the TAG on Radiological Protection (T/AST/038) (Ref. 3) and in the IAEA Safety Guide on Radiation Protection Aspects of Design for Nuclear Power Plants, NS-G-1.13 (Ref. 5) (see Section 4.3.3).

4.2.5.2.1 Methodology for the Radiological Zoning Scheme – Radiological Protection

Assessment

71 The response to TQ-EPR-1498 (Ref. 16) from EDF and AREVA regarding the methodology for the radiological zoning scheme and the relationship between accessibility and classification is summarised in Sub-section 4.2.5.1.1.

72 EDF and AREVA based the classification of rooms on accessibility requirements which took account of expected maintenance requirements and experience feedback, and this was consistent with international standards (Ref. 5).

73 The response to TQ-EPR-1498 (Ref. 16) stated that the amount of shielding was adapted to reach at least a maximum dose rate based on the access requirements. However, the evidence provided in the overview radiological zoning document (Ref. 20) showed that the calculated dose rates in most areas were below the maximum dose rates based on access requirements, and were therefore consistent with the principle of restricting radiation exposure SFAIRP in IRR99 (Ref. 24).

Findings

74 In my opinion, and in the opinion of the TSC, from the evidence provided, the methodology of calculating dose rates for rooms without sources (by using the dose rate of neighbouring rooms) and dose rates for rooms with sources (by using the maximum dose rate at 0.5m from equipment emitting the highest dose rate) was consistent with international relevant good practice.

75 In my opinion, and in the opinion of the TSC, from the evidence provided, the approach to radiological zoning of the buildings in the nuclear island regarding radiological protection was consistent with relevant good UK and international practice.

4.2.5.2.2 Dose Rates for Similar Systems – Radiological Protection

Assessment

76 During the review of the overview radiological zoning document (Ref. 20) it was noted that there were differences in dose rates for "similar" systems. For example, there were differences in dose rates during shutdown conditions between the SGs in loop 1 compared to the other SGs. The response to TQ-EPR-1498 covered this matter and provided additional information which was summarised in Sub-section 4.2.5.1.2 regarding dose rates for similar systems.

Findings

77 In my opinion, and in the opinion of the TSC, from the evidence provided, calculating the dose rate only for one part of the plant and using the results for symmetrical rooms based on similarity considerations may be considered a comprehensible approach. However, without the explanations provided in the response to TQ-EPR-1498 (Ref. 16) regarding the upper boundary of the dose rate range being used for other symmetrical rooms to demonstrate that the dose rate calculations were not performed in these particular rooms, the figures in the overview radiological zoning document (Ref. 20) could be considered inconsistent.

78 In my opinion, and in the opinion of the TSC, from the evidence provided, the approach taken on dose rates for similar systems was pragmatic and appropriate, and an explanation was included in the next revision of the overview radiological zoning document (Ref. 21).

4.2.6 Reactor Building

79 This part of my Assessment Report summarises the shielding and radiological protection assessment of topic areas that are relevant to the Reactor Building, namely shielding provisions for walls, slabs and shield doors, and radiological protection aspects of frequently accessed and restricted zones and annulus rooms.

4.2.6.1 Reactor Building - Shielding

80 The following Sub-sections 4.2.6.1.1 and 4.2.6.1.2 summarise the assessment and findings of shielding provisions for walls, slabs and shield doors. During the assessment I raised TQ-EPR-1499 (Ref. 16) in consultation with the TSC, NT, to request further clarification relating to these shielding provisions.

81 Expectations on shielding are in RP.6 of the SAPs (Ref. 2) and in the TAG on Radiation Shielding (T/AST/002) (Ref. 3) (see Section 4.3.2). In particular, guidance on the validity of shielding calculations is in paragraph 4.1.2 of Section 4.1 on Source Term Generation,

and guidance on solid shielding materials is in Section 4.5 and Appendix 1 of the TAG on Radiation Shielding (T/AST/002) (Ref. 3).

4.2.6.1.1 Walls and Slabs - Shielding

Assessment

82 Based on shielding samples provided during Step 4, NT's Step 4 GDA shielding review concluded that bulk shielding provisions and calculated dose rates for the Reactor Building during operation at power were acceptable based on the anticipated occupancy requirements (e.g. access to the service space seven days before shutdown, where the "two room concept" allowed workers to enter the service space with the reactor at power but not the equipment compartment, as discussed in Ref. 7) (Ref. 31).

83 A review of the additional information in the response to TQ-EPR-1499 (Ref. 16), along with the plant layout drawings submitted in response to TQ-EPR-593 during Step 4 (Ref. 13), indicated that shielding provisions and predicted dose rates for all areas of the Reactor Building during power operation and shut down would be acceptable (Ref. 18).

Findings

84 In the opinion of the TSC, from the evidence provided, the bulk shielding provisions for walls and slabs were acceptable in the Reactor Building. I concur with the opinion of the TSC from the evidence provided regarding the adequacy of bulk shielding provisions for walls and slabs in the Reactor Building.

4.2.6.1.2 Shield Doors - Shielding

Assessment

85 During the review of the overview radiological zoning document (Ref. 20), it was unclear whether the radiological zoning and dose rates within the Reactor Building assumed that the shield doors between areas were open or closed. Following discussions with EDF and AREVA, I raised TQ-EPR-1499 (Ref. 16) to request EDF and AREVA to confirm the following.

- Shield doors within the Reactor Building had been specified in order to reduce dose rates to "green" zone levels (see Table 2) in accessible areas within the Reactor Building during power operation.
- Shielding calculations and radiological zoning for the Reactor Building during outages assumed that all of the shield doors were open (no shield doors were present).

86 The response to TQ-EPR-1499 (Ref. 16) from EDF and AREVA provided additional information on shield doors that included the following.

- As a preliminary conservative assumption, all the doors of the controlled area were not modelled for dose rate calculations for the UK EPR™ design during outages.
- If dose rate accessibility requirements were exceeded with shield doors open such that additional shielding was required, then shield doors were included in the three-dimensional mock-up. Gamma shield doors were made of steel only (or made of lead outside the Reactor Building) and neutron / gamma shield doors were made of layers of steel / polyethylene / steel. Calculations were repeated with these shield doors in a closed position to check that accessibility requirements were met.
- All other non-shield doors (where the thickness of the door was not specified by the radiological protection designer) were not modelled (either open or closed).

- For the Reactor Building, even if shield doors had been required for operation at power, they were not modelled for outages because there was a possibility that such doors could be left open by workers for long periods of time.
- The results of the dose rate calculations showed that the layout and civil works were such that the dose rates for the majority of the rooms of the Reactor Building during outages met the dose rate requirements without any modelling of shield doors being required. Only in a few cases did calculated dose rates exceed relevant criteria locally around a door (although dose rate criteria were met a short distance away). In such cases, mobile monitoring after the commissioning of the plant would check if the dose rate criteria were actually exceeded. If this was the case, the relevant doors would be kept closed unless required for access.

87 In addition to the above clarification regarding the methodology for assessing shield doors, EDF and AREVA provided additional information regarding the assessment of the shield door to the reactor pit ventilation room at a specified level in the Reactor Building in the response to TQ-EPR-1499 (Ref. 16). The initial shielding calculations (assuming the reactor was at full power during operation) showed that dose rates through the unshielded door opening were in excess of the design criteria at the cold-side. This led to the shielding provision of a steel / polythene shield door in order to reduce the neutron dominant dose rates to acceptable “green” zone levels (see Table 2).

88 As described above, the dose rates at the cold-side of the door were also calculated using outage source terms without the door present which showed that the cold-side dose rates were within the “green” zone criteria (see Table 2) when the door was open.

Findings

89 In the opinion of the TSC, from the evidence provided, the information provided by EDF and AREVA showed that the shielding provisions for shield doors within the Reactor Building had been based on worst-case source terms (during operation at full power). Additional calculations assuming outage source terms showed that radiological zoning criteria (outlined in Ref. 20) would be met when doors were open during outages. This approach regarding the identification, analysis and specification of shield doors was considered to be both conservative and consistent with relevant good UK and international practice. I concur with the opinion of the TSC from the evidence provided on shielding provisions for shield doors in the Reactor Building.

4.2.6.2 Reactor Building - Radiological Protection

90 The following Sub-sections 4.2.6.2.1 and 4.2.6.2.2 summarise the assessment and findings of radiological protection aspects of frequently accessed and restricted zones and of annulus rooms. During the assessment I raised TQ-EPR-1499 (Ref. 16) in consultation with the TSC, TUV SUD, to request further clarification relating to these radiological protection aspects.

91 Expectations on radiological protection and designation of areas are in RP.3 of the SAPs (Ref. 2) and in the TAG on Radiological Protection (T/AST/038) (Ref. 3) (see Section 4.3.3). In particular, guidance on higher category zones for radiation, contamination and airborne activity being nested within less highly categorised zones are in paragraph 485 of the SAPs (Ref. 2), in paragraph 4.7 of the TAG on radiological protection (T/AST/038) (Ref. 3) and in paragraphs 4.1 and 4.12(4) of the TAG on ventilation (T/AST/022) (Ref. 3).

4.2.6.2.1 Frequently Accessed and Restricted Zones - Radiological Protection

Assessment

92 The calculated dose rates of all rooms in the Reactor Building during operation at power and during shut down were listed in the overview radiological zoning document (Ref. 20). This showed that all the high-occupancy access areas, especially access corridors, stairways and maintenance floors were classified as “green” zones (see Table 2). The “red” zones (Prohibited Areas, see Table 2) during operation at power were not accessible.

Findings

93 In my opinion, and in the opinion of the TSC, from the evidence provided, the maximum dose rate of less than 10 microSvh-1 for high access areas (“green” zone, see Table 2) was consistent with requirements in IRR99 (Ref. 24) regarding restricting exposures SFAIRP, and was consistent with relevant good practice in the best operating NPPs abroad.

94 In my opinion, and in the opinion of the TSC, from the evidence provided, the classification of the “red” zones (see Table 2) was appropriate since no access needs were identified that required entry to these zones during power operation.

95 In my opinion, and in the opinion of the TSC, from the evidence provided, there was no need to cross high dose rate areas in order to access rooms with lower dose rates within the Reactor Building. This was consistent with requirements in IRR99 (Ref. 24) regarding restricting exposures SFAIRP and, in particular, with the advice in paragraph 485 of RP.3 of the SAPs (Ref. 2) and in the TAGs on Radiological Protection (T/AST/038) and on Ventilation (T/AST/022) (Ref. 3).

4.2.6.2.2 Annulus Rooms – Radiological Protection

Assessment

96 The dose rates in the five annulus rooms (north-east, east, south, west and north-west) at a specified level in the Reactor Building were listed as 25microSvh-1 during shutdown (Ref. 20). This was inconsistent as neighbouring areas were classified as having dose rates of less than 10microSvh-1 (“green” zone, see Table 2) and no additional sources were present. The response to TQ-EPR-1499 (Ref. 16) provided additional information on these five specific annulus rooms which included the following.

- The accessibility requirements inside the Reactor Building for the outage phase and during power operation focused on the annular spaces and the service floor (i.e. rooms located within the containment of the building).
- Access to the annulus rooms between the double containment walls was only expected for occasional maintenance on piping, valves and ventilation equipment. Therefore, there was no dose rate criterion for accessibility requirements in these particular annulus rooms compared to the annular spaces and the service floor inside the containment which were required to be accessible as “green” zones with dose rates lower than 25microSvh^{-1}, or lower than 10microSvh^{-1} in case of more frequent access (see Table 2).
- Since the annulus rooms were open from one to another through the overall height of the Reactor Building (most of them were only separated by steel grating), the dose rate calculations had been undertaken up to a 25microSvh^{-1} (“green” zone, see Table 2) dose rate criterion. Once undertaken, all the upper annulus rooms had been set to the maximum dose rate of 25microSvh^{-1} (“green” zone, see Table 2)

even though the dose rate within these rooms was expected to be lower (since there were no additional sources in the upper annulus rooms).

Findings

97 In my opinion, and in the opinion of the TSC, from the evidence provided, calculating the dose rate for only one part of the plant and using those results to identify the maximum dose rate of the relevant zone for symmetrical rooms was a pragmatic, conservative and appropriate approach. This is similar to the discussion on similar systems regarding SGs in Sub-sections 4.2.5.1.2 and 4.2.5.2.2 above.

4.2.7 Fuel Building

98 This part of my Assessment Report summarises the shielding and radiological protection assessment of topic areas that are relevant to the Fuel Building, namely shielding provisions for and radiological protection aspects of the exit air lock, access corridor, pool control room, fuel loading hall and hydrogenous equipment room.

4.2.7.1 Fuel Building – Shielding

99 The following Sub-sections 4.2.7.1.1, 4.2.7.1.2 and 4.2.7.1.3 summarise the assessment and findings of shielding provisions for the exit air lock, access corridor, pool control room, fuel loading hall and hydrogenous equipment room. During the assessment I raised TQ-EPR-1500 (Ref. 16) in consultation with the TSC, NT, to request further clarification relating to these shielding provisions.

100 Previous review / analysis of the shielding provisions for the priority rooms within the Fuel Building (Refs 31 and 36) provided examples of how shielding provisions had been assessed and, where necessary, optimised to ensure that bulk shielding and dose rates met the radiological zoning criteria as described in Refs 32, 33 and 34.

101 Further review of the bulk shielding within the Fuel Building based on the radiological zoning for the EPR (Ref. 20) and the building layout drawings provided in response to TQ-EPR-593 during Step 4 (Ref. 13) were performed as part of this review. Given the level of information available, the review considered whether the bulk shield walls between rooms generally reflected the changes in radiological zoning outlined in the overview radiological zoning document (Ref. 20).

102 No significant issues were raised during this review. However, in line with the GDA sampling process, further details were requested from EDF and AREVA to clarify the dose rates and radiological classifications for an exit air lock, access corridor, pool control room, fuel loading hall and hydrogenous equipment room.

103 Expectations on shielding are in RP.6 of the SAPs (Ref. 2) and in the TAG on Radiation Shielding (T/AST/002) (Ref. 3) (see Section 4.3.2).

4.2.7.1.1 Exit Air Lock, Access Corridor and Pool Control Room - Shielding

Assessment

104 TQ-EPR-1500 (Ref. 16) requested additional information on an air lock, access corridor and pool control room. In each case, the classification was 2.5A (25microSvh-1, “green” zone, see Table 2) and the TQ challenged why they did not meet the criteria for class A (10microSvh-1, “green” zone, see Table 2) since such rooms / areas would usually be classified as an A zone.

105 The response from EDF and AREVA to TQ-EPR-1500 (Ref. 16) included the following.

- The only radiation sources in these three rooms were Nuclear Island Vent and Drain System (RPE) pipes, and since the RPE system was classified as 2.5A, these rooms were given the same classification.
- Further analysis was performed on these pipes which were used to evacuate effluent coming from floor drains of an access corridor, annulus access airlock and pool cranes control floor on upper levels. These pipes would only be used during decontamination operations in these upper rooms, and so would only be temporarily contaminated in the air lock, access corridor and pool control room below.
- Consequently, the air lock, access corridor and pool control room were reclassified as class A (10microSvh^{-1}, "green" zone, see Table 2).

Findings

106 In the opinion of the TSC, from the evidence provided, the re-classification of the air lock, access corridor and pool control room from class 2.5A to A (all in the "green" zone, see Table 2) was appropriate. I concur with the opinion of the TSC on the evidence provided regarding the re-classification of the air lock, access corridor and pool control room.

4.2.7.1.2 Fuel Loading Hall - Shielding

Assessment

107 TQ-EPR-1500 (Ref. 16) requested additional information on the fuel loading hall during fuel handling which had a dose rate of over 1mSvh-1 ("yellow" zone, see Table 2) during fuel handling, and in particular, on access requirements, radiation sources, dose rate progression during fuel handling and positions of workers in the fuel loading hall.

108 The response from EDF and AREVA to TQ-EPR-1500 (Ref. 16) included the following.

- During fuel handling, the radiation source was spent fuel (SF) which came from the unloading pit above and was put into a shielded cask with a biological (shielded) plug.
- A study was undertaken to define the shielding requirements of the plug. Gamma radiation and neutrons emitted from the SF were evaluated to establish the radiation sources, and these were used to calculate dose rates for a range of scenarios, including when casks were full but not plugged, when casks were moving and when casks were being plugged. Dose rates were calculated at three different worker locations on plant.
- The shielding provisions to protect workers from radiation included the cask body, (made from stainless steel with a layer of polyethylene resin), the concrete floor between the fuel handling hall and the unloading pit, and the biological protection slab which covered the whole penetration when the fuel assembly was loaded through the penetration into the cask (the biological slab was made from carbon steel).

Findings

109 In the opinion of the TSC, from the evidence provided, the shielding arrangements and dose rates were acceptable. I concur with the opinion of the TSC from the evidence provided on shielding arrangements in the fuel loading hall.

4.2.7.1.3 Hydrogenous Equipment Room - Shielding

Assessment

110 TQ-EPR-1500 (Ref. 16) requested additional information on the hydrogenous equipment room where half the room was class C and the other half was class D (1mSvh-1 and 10mSvh-1, "yellow" and "orange" zones, respectively, see Table 2), separated only by a fence. In particular, the TQ asked whether this was due to fall-off of dose rates or to local shielding.

111 The response from EDF and AREVA to TQ-EPR-1500 (Ref. 16) included the following.

- The hydrogenous equipment room was the hydrogenous station of the chemical and volume control system (RCV) system, and contained a self-controlling device for the concentration of hydrogen in the coolant.
- The source term was used to calculate dose rates which were more than 2.5mSvh^{-1} ("orange" zone, see Table 2) at 50cm from the gas separator (separated from the rest of the room and access door by the fence) and less than 1mSvh^{-1} ("yellow" zone, see Table 2) in the rest of the room.
- There was insufficient space in the room for additional shielding, but since the dose rate was less than 1mSvh^{-1} ("yellow" zone, see Table 2) in the part of the room with the access door, this part of the room was classified as a "yellow" zone and the part of the room housing the gas separator was classified as an "orange" zone (see Table 2). This would allow easier access for workers into the hydrogenous equipment room and would avoid inadvertent access into the higher dose rate "orange" zone (see Table 2).

112 The provision of a restrictive barrier (fence) as opposed to bulk shielding was a good balance between access and radiological protection and was in accordance with relevant good shielding practice.

Findings

113 In the opinion of the TSC, from the evidence provided, the shielding arrangements and the provision of the fence were acceptable and were consistent with relevant good shielding practice. I concur with the opinion of the TSC from the evidence provided on shielding arrangements in the hydrogenous equipment room.

4.2.7.2 Fuel Building - Radiological Protection

114 The following Sub-sections 4.2.7.2.1, 4.2.7.2.2 and 4.2.7.2.3 summarise the assessment and findings of radiological protection aspects of the exit air lock, access corridor, pool control room, fuel loading hall and hydrogenous equipment room. During the assessment I raised TQ-EPR-1500 (Ref. 16) in consultation with the TSC, TUV SUD, to request further clarification relating to these radiological protection aspects.

115 Expectations on radiological protection and designation of areas are in RP.3 of the SAPs (Ref. 2) and in the TAG on Radiological Protection (T/AST/038) (Ref. 3) (see Section 4.3.3). In particular, guidance on higher category zones for radiation, contamination and airborne activity being nested within less highly categorised zones are in paragraph 485 of the SAPs (Ref. 2), in paragraph 4.7 of the TAG on radiological protection (T/AST/038) (Ref. 3) and in paragraphs 4.1 and 4.12(4) of the TAG on ventilation (T/AST/022) (Ref. 3).

4.2.7.2.1 Exit Air Lock, Access Corridor and Pool Control Room – Radiological Protection

Assessment

116 TQ-EPR-1500 (Ref. 16) requested additional information on an air lock, access corridor and pool control room. In each case, the classification was 2.5A (25microSvh-1, see Table 2) and the TQ challenged why they did not meet the criteria for class A (10microSvh-1, see Table 2), since such rooms / areas would usually be classified as class A.

117 The response from EDF and AREVA to TQ-EPR-1500 (Ref. 16) is summarised in Sub-section 4.2.7.1.1. In brief, in view of the nature of the contamination in the RPE pipes, further analysis was undertaken which showed that these pipes would only be used during decontamination operations, and the air lock, access corridor and pool control room were reclassified as class A (10microSvh-1, see Table 2).

118 All the high access areas, especially access corridors, stairways and maintenance floors were classified as “green” zones (see Table 2) (Ref. 20). As the air lock, access corridor and pool control room would all require frequent access, the re-classification to 10microSvh-1 (“green” zone, see Table 2) was appropriate. It is reasonable to temporarily increase the dose rates up to 25microSvh-1 (“green” zone, see Table 2) in these rooms during decontamination of relevant facilities on the upper levels.

Findings

119 In my opinion, and in the opinion of the TSC, from the evidence provided, the review of the overview radiological zoning document (Ref. 20) showed that there was no need to cross high dose rate areas in order to access rooms with lower dose rates within the Fuel Building. This was consistent with the requirements in IRR99 (Ref. 24) regarding restricting exposure SFAIRP and, in particular, with the advice in paragraph 485 of RP.3 of the SAPs (Ref. 2) and in the TAGs on Radiological Protection (T/AST/038) and on Ventilation (T/AST/022) (Ref. 3).

120 In my opinion, and in the opinion of the TSC, from the evidence provided, the maximum dose rate of less than 10microSvh-1 (“green” zone, see Table 2) for high access areas was consistent with the requirements in IRR99 (Ref. 24) regarding restricting exposure SFAIRP and with relevant good practice for the best operating NPPs abroad.

121 In my opinion, and in the opinion of the TSC, from the evidence provided, the re-calculated radiological classification of the air lock, access corridor and pool control room was consistent with national and international relevant good practice.

4.2.7.2.2 Fuel Loading Hall - Radiological Protection

Assessment

122 TQ-EPR-1500 (Ref. 16) requested additional information on the fuel loading hall during fuel handling (which had a maximum dose rate of more than 1mSvh-1 during fuel handling) and, in particular, on access requirements, radiation sources, dose rate progression during fuel handling and positions of workers in the fuel handling hall.

123 The response from EDF and AREVA to TQ-EPR-1500 (Ref. 16) is summarised in Sub-section 4.2.7.1.2. In brief, a study was undertaken to define the shielding provisions during fuel handling. Gamma radiation and neutron dose rates were calculated for a range of operating scenarios and were calculated at three different worker locations. The shielding provisions to protect workers from radiation included the cask body, the concrete floor between the fuel handling hall and the unloading pit, and the biological protection slab.

124 As the fuel transfer was done automatically, the dose rates in the fuel loading hall during fuel handling operations were acceptable even though the highest dose rates were not insignificant (the calculated dose rates to which workers would be exposed in the scenarios identified ranged from approx. 20microSvh-1 ("green" zone, see Table 2) to more than 1mSvh-1 ("yellow" zone, see Table 2)). The response from EDF and AREVA to TQ-EPR-1500 (Ref. 16) showed that detailed radiological studies for the event of failure of the Spent Fuel Cask Transfer Facility had been performed; I did not assess these studies.

Findings

125 In my opinion, and in the opinion of the TSC, from the evidence provided, in view of the not insignificant calculated dose rates in the fuel loading hall during fuel handling operations, engineered or administrative measures should be adopted to restrict access of workers to the fuel handling hall during such high dose rate operations.

126 I have identified a GDA Assessment Finding on restriction of access to personnel during periods when high dose rates are present in the fuel loading hall in the Fuel Building during fuel handling operations as follows.

> ***AF-UKEPR-RP-21:*** *The future licensee shall provide ALARP justifications and procedures to provide engineering or administrative measures to restrict access of personnel into areas during periods when high dose rates are present. This shall include the following.*
>
> *(a) The future licensee shall provide an ALARP justification for workers in the fuel loading hall (HK1015ZL) in the Fuel Building during the special case of fuel handling operations and shall provide procedures involving engineering or administrative measures to restrict access of workers to that hall during such fuel handling operations, as necessary.*
>
> *(b) – (e) See Sub-section 4.2.8.2.1.*
>
> *(f) See Sub-section 4.2.9.2.*
>
> ***Required timescale:*** *This shall be completed before fuel on site.*

4.2.7.2.3 Hydrogenous Equipment Room - Radiological Protection

Assessment

127 TQ-EPR-1500 (Ref. 16) requested additional information on the hydrogenous equipment room where the classification of the room was split into two halves separated by a fence (half the room was class C and the other half was class D, namely, 1mSvh-1 and 10mSvh-1, "yellow" and "orange" zones, respectively (see Table 2)).

128 The response from EDF and AREVA to TQ-EPR-1500 (Ref. 16) is summarised in Sub-section 4.2.7.1.3. In brief, the hydrogenous equipment room was the hydrogenous station of the RCV system which contained a self-controlling device for the concentration of hydrogen in the coolant. The dose rates were more than 2.5mSvh-1 ("orange" zone, see Table 2) at 50cm from the gas separator and less than 1mSvh-1 ("yellow" zone, see Table 2) in the rest of the room, and the fence prevented inadvertent access into the higher dose rate area (i.e. it prevented inadvertent access from the "yellow" zone into the "orange" zone, see Table 2).

129 In view of the lack of space for additional shielding, the provision of a restrictive barrier (fence) as opposed to bulk shielding was a good balance between access and radiological protection and was in accordance with relevant good shielding practice.

Findings

130 In my opinion, and in the opinion of the TSC, from the evidence provided, allowing two radiological classifications within one room is appropriate for dose optimisation and is in accordance with relevant good practice so long as access to the higher dose rate area is controlled (in this case by a fence).

4.2.8 Nuclear Auxiliary Building

131 This part of my Assessment Report summarises the shielding and radiological protection assessment of topic areas that are relevant to the Nuclear Auxiliary Building, including radiological protection aspects of the nuclear sampling system (REN) sampling box room, valve room, storage room for low activity waste, filter compartment room, mixed bed filter rooms and maintenance floor.

4.2.8.1 Nuclear Auxiliary Building - Shielding

132 This Sub-section summarises the assessment and findings of shielding provisions for the Nuclear Auxiliary Building. During the assessment I raised TQ-EPR-1501 (Ref. 16) in consultation with the TSC, NT, to request further clarification relating to these shielding provisions.

133 Expectations on radiation shielding are in RP.6 of the SAPs (Ref. 2) and in the TAG on Radiation Shielding (T/AST/002) (Ref. 3) (see Section 4.3.2).

Assessment

134 No significant issues were raised during the review of the bulk shielding provisions for the Nuclear Auxiliary Building based on the overview radiological zoning document (Ref. 20) and building layouts provided in the response to TQ-EPR-593 during Step 4 (Ref. 13). Additional information regarding the shielding provisions and dose rates in the mixed filter bed and filter compartments were provided by EDF and AREVA in response to TQ-EPR-1501 (Ref. 16) and are summarised in Sub-section 4.2.8.2.2.

Findings

135 In the opinion of the TSC, from the evidence provided, the additional information provided in response to TQ-EPR-1501 (Ref. 16) suggested that there were adequate shielding provisions to reduce dose rates to acceptable levels given the anticipated occupancy requirements for operations in this area. I concur with the opinion of the TSC from the evidence provided on shielding provisions in the Nuclear Auxiliary Building.

4.2.8.2 Nuclear Auxiliary Building - Radiological Protection

136 The following Sub-sections 4.2.8.2.1, 4.2.8.2.2 and 4.2.8.2.3 summarise the assessment and findings of radiological protection aspects of: the dual classification of the REN sampling box room, valve room and storage room for low activity waste; dose rates and access to mixed bed filter rooms and filter compartments; and dose rates on the maintenance floor. During the assessment I raised TQ-EPR-1501 (Ref. 16) in consultation with the TSC, TUV SUD, to request further clarification relating to these radiological protection aspects.

137 Expectations on radiological protection and designation of areas are in RP.3 of the SAPs (Ref. 2) and in the TAG on Radiological Protection (T/AST/038) (Ref. 3) (see Section 4.3.3). In particular, guidance on higher category zones for radiation, contamination and airborne activity being nested within less highly categorised zones are in paragraph 485 of the SAPs (Ref. 2), in paragraph 4.7 of the TAG on radiological protection (T/AST/038) (Ref. 3) and in paragraphs 4.1 and 4.12(4) of the TAG on ventilation (T/AST/022) (Ref. 3).

4.2.8.2.1 REN Sampling Box Room, Valve Room and Storage Room for Low Activity Waste – Radiological Protection

Assessment

138 The calculated dose rates of all rooms of the Nuclear Auxiliary Building during operation at power and during shut down were listed in the overview radiological zoning document (Ref. 20). This showed that all the high access areas, especially access corridors, stairways and maintenance floors, were classified as “green” zones (see Table 2).

139 During the review of the overview radiological zoning document (Ref. 20) it was noted that the classification of the REN sampling box, valve room and storage room for low activity waste showed discrepancies between the information presented in different sections of Ref. 20. The response to TQ-EPR-1501 (Ref. 16) provided additional information on the REN sampling box and valve room which included the following.

- The REN sampling box and valve room were located next to the RCV mixed bed de-mineraliser rooms. The de-mineralisers were used for coolant purification. When the de-mineralisers were working, the resins inside retained the activity of the coolant and would become highly radioactive.
- During power operation, the REN sampling box and valve room were protected by a thick concrete wall. The REN sampling box was classified as a “green” zone and the valve room as a “yellow” zone (see Table 2).
- When the resins needed to be changed, they were flushed automatically through pipes circulating in the valve room. Due to the high radioactivity of the resins, the impact on the dose rates in the REN sampling box was that the room was temporarily classified as a class C “yellow” zone ($1mSvh^{-1}$), and the valve room was temporarily classified as a class F “red” zone ($1Svh^{-1}$) during resin flushing operations (see Table 2). During this phase, access to the REN sampling box room was regulated and access to the valve room was prohibited.
- The dual classification of the REN sampling box and valve room was not included in the table of the overview radiological zoning document (Ref. 20), and this would be corrected in the next revision of the overview document (Ref. 21).

140 The response to TQ-EPR-1501 (Ref. 16) provided additional information on the storage room for low activity waste which included the following.

- The storage room for low activity waste was classified as a “green” zone (see Table 2) since only low level waste was transferred through this room. However, it would be possible to temporarily store waste bags with a contact dose rate higher than $2mSvh^{-1}$ (“yellow” zone, see Table 2), especially during an outage when there would be a lot of maintenance work to perform. If this occurred, then the storage room would be classified temporarily as an “yellow” zone (see Table 2).
- The dual classification of the storage room for low activity waste was not included in the table of the overview radiological zoning document (Ref. 20), and this would be corrected in the next revision of the overview document (Ref. 21).

Findings

141 In my opinion, and in the opinion of the TSC, from the evidence provided, the maximum dose rate of 10 microSvh-1 for high access areas was consistent with requirements in IRR99 regarding restricting exposure SFAIRP (Ref. 24). This was relevant good practice and comparable with the best operating NPPs abroad.

142 In my opinion, and in the opinion of the TSC, from the evidence provided, there was no need to cross high dose rate areas in order to access rooms with lower dose rates within the nuclear auxiliary building. This was consistent with the requirements of the IRR99 (Ref. 24) and in particular, with the advice in paragraph 485 of RP.3 of the SAPs (Ref. 2) and in the TAGs on Radiological Protection (T/AST/038) and on Ventilation (T/AST/022) (Ref. 3).

143 In my opinion, and in the opinion of the TSC, from the evidence provided, the dual classification of the REN sampling box, valve room and storage room for low activity waste room was appropriate. However, in view of the high dose rates in these rooms during flushing of the resins in the RCV mixed bed de-mineralisers and during the storage of highly radioactive waste packages, I recommend that during the construction and commissioning phase, the provision of adequate technical or administrative measures to restrict the access of personnel to those rooms when high dose rates are present should be implemented.

144 I have identified a GDA Assessment Finding on restriction of access to personnel during periods when high dose rates are present in the Nuclear Auxiliary Building involving the REN sampling box and valve room during resin flushing operations, and the storage room for low activity waste when highly radioactive waste packages are stored in the room, as follows.

> ***AF-UKEPR-RP-21:*** *The future licensee shall provide ALARP justifications and procedures to provide engineering or administrative measures to restrict access of personnel into areas during periods when high dose rates are present. This shall include the following.*
>
> *(a) See Sub-section 4.2.7.2.2.*
>
> *(b) The future licensee shall provide an ALARP justification for workers in the REN sampling box room (HNX0663ZL) in the Nuclear Auxiliary Building during the special case of resin flushing operations and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during such resin flushing operations, as necessary.*
>
> *(c) The future licensee shall provide an ALARP justification for workers in the valve room (HNX0670ZL) in the Nuclear Auxiliary Building during normal operation and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during normal operation, as necessary.*
>
> *(d) The future licensee shall prevent access of workers to the valve room (HNX0670ZL) in the Nuclear Auxiliary Building during the special case of resin flushing operations and shall provide procedures involving engineering or administrative measures to prevent access of workers to that room during such resin flushing operations, as necessary.*

(e) The future licensee shall provide an ALARP justification for workers in the storage room for low activity waste (HNX1794ZL) in the Nuclear Auxiliary Building during the special case of highly radioactive waste packages being stored in that room and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during such storage operations, as necessary.

(f) See Sub-section 4.2.9.2.

***Required timescale:** This shall be completed before fuel on site.*

4.2.8.2.2 Filter Compartment Room and Mixed Bed Filter Rooms – Radiological Protection Assessment

145 During the review of the overview radiological zoning document (Ref. 20) it was noted that the classification of the filter compartment room was class 3F (3Svh-1, "red" zone, see Table 2) with a calculated maximum dose rate of approx. 2Svh-1. The classification of the mixed bed filter rooms ranged from class 3D to class G (from 30mSvh-1 to 10Svh-1, "orange" to "red" zones, respectively, see Table 2) with calculated maximum dose rates of less than 20mSvh-1 to more than 3Svh-1. The response to TQ-EPR-1501 (Ref. 16) provided additional information on the dose rates and shielding provisions in these rooms, and on access requirements for maintenance and repairs in the mixed bed filter rooms. Information on the filter compartment room included the following.

- The filter compartment room housed the RCV, coolant storage and treatment system (TEP), RPE and fuel pool cooling and purification system (PTR) filters. The filters would be replaced when differential pressure or dose rate criteria were exceeded. The maximum dose rate at the surface of the filter cartridge rack was predicted to be approx. $2Svh^{-1}$ and so the classification of the room was $2Svh^{-1}$ (class 3F, "red" zone, see Table 2).
- The adjacent rooms were shielded by concrete walls of different thicknesses for adjacent "yellow" and "green" zones (see Table 2).
- The upper floor was shielded with shielding plugs over each filter compartment, and each plug had the shielding equivalent of approx. 25cm of steel.
- When a filter had to be changed, the operator used a dedicated filter changing machine. The changing machine opened the plug and took out the filter into a shielded compartment in the machine. Due to the shielding in the body of the changing machine, the operator of the machine was in a "green" zone (see Table 2) during the whole operation.
- No regular maintenance was required in the filter compartment. If additional maintenance would be required, the active filters could be removed before the work began so that the ambient dose rate would become tolerable.

146 Information on the mixed bed filter rooms included the following.

- These rooms were the RCV and PTR mixed bed de-mineraliser rooms. The adjacent rooms and the upper rooms were shielded by thick concrete walls / floors.
- No regular maintenance was required in these rooms because the main operation was to change the resins which was done automatically. If maintenance work was required, then the active resins could be flushed with clean water to reduce levels of contamination. Dose rates following flushing of the de-mineralisers were not

calculated since these would depend on the thoroughness of the flushing, and the amount of flushing required to reach a dose rate criterion for a particular task would depend in part on the duration of the planned maintenance operation.

- Access into these rooms was through the concrete moveable ceiling and down an access ladder.

Findings

147 In my opinion, and in the opinion of the TSC, from the evidence provided, the calculated dose rate of up to 2mSvh-1 ("yellow" zone, see Table 2) in the filter compartment room was reasonable since regular access was not required. In the event of equipment failure, the filters could be removed to reduce the dose rates in the room to enable workers to enter, and such contributions to optimisation of dose would be consistent with relevant good practice.

148 In my opinion, and in the opinion of the TSC, from the evidence provided, since changing the resins in the mixed bed filter rooms would be performed remotely, the calculated dose rate of up to 3Svh-1 ("red" zone, see Table 2) in these rooms was reasonable since regular access was not required. In the event of equipment failure or if maintenance work was required, the active resins could be flushed with clean water to reduce levels of contamination and reduce the dose rates in the room to enable workers to enter. Such contributions to optimisation of dose would be consistent with relevant good practice.

4.2.8.2.3 Maintenance Floor – Radiological Protection

Assessment

149 During the review of the overview radiological zoning document (Ref. 20) it was noted that the dose rate of the maintenance floor was class 2.5A (25microSvh-1, "green" zone, see Table 2). TQ-EPR-1501 requested information on access requirements and the types of maintenance undertaken in this room, and questioned why the room was not class A (10microSvh-1, see Table 2). The response to TQ-EPR-1501 (Ref. 16) provided additional information on the maintenance floor which included the following.

- This room contained a RPE pipe, gaseous waste processing system (TEG) pipes and TEG manual valves. The pipes were slightly radioactive and emitted dose rates of less than 25microSvh^{-1} (class 2A, "green" zone, see Table 2). During normal operation, access was not required to this room, and access was only required to open or close the TEG manual valves before maintenance was carried out in other rooms. Since the opening and closing of the valves took little time and was not a regular operation, the need to add additional shielding to reduce the room to class A (10microSvh^{-1}, "green" zone, see Table 2) was not considered ALARP.

Findings

150 In my opinion, and in the opinion of the TSC, from the evidence provided, to retain the maintenance floor as class 2.5A (rather than reducing it to class A, both "green" zones, see Table 2) was reasonable and ALARP, and was consistent with optimisation in national and international relevant good practice.

4.2.9 Safeguard Buildings

151 This part of my Assessment Report summarises the shielding and radiological protection assessment of topic areas that are relevant to the Safeguard Buildings, including shielding provisions for rooms "For Special Use", medium head safety injection (RIS) pump room and supply air shaft.

4.2.9.1 Safeguard Buildings - Shielding

152 The following Sub-sections 4.2.9.1.1, 4.2.9.1.2 and 4.2.9.1.3 summarise the assessment and findings of shielding provisions for the rooms "For Special Use" (for circulation of pipes) and RIS pump room, and shielding for accident conditions for the supply air shaft. During the assessment I raised TQ-EPR-1502 (Ref. 16) in consultation with the TSC, NT, to request further clarification relating to these shielding provisions.

153 Expectations on radiation shielding are in RP.6 of the SAPs (Ref. 2) and in the TAG on Radiation Shielding (T/AST/002) (Ref. 3) (see Section 4.3.2). In particular, guidance on restriction of exposure regarding shielding for normal operations and accidents is in paragraph 2.12 of Section 2 on the Relationship to Licence and Other Relevant Legislation, guidance on the validity of shielding calculations is in paragraph 4.1.2 of Section 4.1 on Source Term Generation, and guidance on solid shielding materials is in Section 4.5 and Appendix 1 of the TAG on Radiation Shielding (T/AST/002) (Ref. 3).

4.2.9.1.1 Rooms "For Special Use" - Shielding

Assessment

154 The purpose of the rooms "For Special Use" was not clear. As they required concrete shielded labyrinths, I requested information on the purpose of the rooms and details of occupancy requirements, sources and shielding calculations in TQ-EPR-1502 (Ref. 16). The response to TQ-EPR-1502 (Ref. 16) from EDF and AREVA provided additional information on the rooms "For Special Use" which included the following.

- The rooms were dedicated areas for the circulation of pipes from systems shared between the four Safeguard Buildings, e.g. TEG, containment heat removal system (EVU), RPE and demineralised water distribution system (SED).
- Of these piping systems, only the TEG and RPE were contaminated. The source terms for the TEG and RPE were provided during Step 4 in response to **RO-UKEPR-73** (Refs 14, 38, 39 and 40).
- The rooms had been created to separate these active piping systems from the stairways of Safeguard Building 2 and Safeguard Building 3, and shielding had been provided by a concrete maze (labyrinth) and a concrete wall to reduce the dose rates to less than 0.02microSvh^{-1} (class A, "green" zone, see Table 2) on the stairways.

Findings

155 In the opinion of the TSC, from the evidence provided, the shielding provisions of concrete labyrinths (as opposed to shield doors which could inadvertently be left open) for the piping systems in the rooms "For Special Use" to ensure that the dose rates in the adjacent high access corridors were class A ("green" zone, see Table 2) was consistent with relevant good practice. I concur with the TSC from the evidence provided on shielding provision for the rooms "For Special Use".

4.2.9.1.2 RIS Pump Room - Shielding

Assessment

156 The classification of the RIS pump room was usually class B ("yellow" zone, see Table 2) and had the potential for the classification to increase to class D ("orange" zone, see Table 2) with only a concrete bulk shield wall and no labyrinth or shield door to protect the adjacent class A corridor ("green" zone, see Table 2). Therefore, I requested information to substantiate the radiological zoning and shielding provisions for the RIS pump room

and adjacent corridor in TQ-EPR-1502 (Ref. 16). The response to TQ-EPR-1502 (Ref. 16) from EDF and AREVA provided additional information on the RIS pump room which included the following.

- In addition to the RIS pump (which would be used during post-accident operation), the RIS pump room also housed piping of the residual heat removal system which was located in a part of the room that was some distance from the door.
- The source term for the RIS pump room was provided during Step 4 in response to **RO-UKEPR-73** (Refs 14, 38 and 40).
- During normal operation, access to the RIS pump room was necessary to carry out periodic tests on the RIS pump, and the room was class B ("yellow" zone, see Table 2).
- During an outage, access to the RIS pump room was not necessary and access was restricted. The residual heat removal system piping contained primary coolant with spikes of radioactivity, during which time the dose rate next to the piping was more than $2mSvh^{-1}$. This gave a temporary increase in room classification to class D ("orange" zone, see Table 2).
- The floor plans would be amended to show this dual classification in the updated radiological zoning classification document (Ref. 21).

Findings

157 In the opinion of the TSC, from the evidence provided, the response to TQ-EPR-1502 (Ref. 16) showed that the room layout with respect to the location of the radiation source (residual heat removal system piping) in relation to the door and the shield walls would ensure that the scattered dose rates into the adjacent "green" zone (see Table 2) would adequately meet the dose rate criterion of less than 10 microSvh-1 (class A, "green" zone, see Table 2) without requiring a shield door. Indeed, this evidence provided a good example of how room layout can be used to reduce shielding requirements whilst maintaining acceptable dose rates in adjacent areas. I concur with the TSC from the evidence provided on shielding provisions for the RIS pump room.

4.2.9.1.3 Supply Air Shaft - Shielding

Assessment

158 During the review of the Safeguard Buildings in the overview radiological protection document (Ref. 20), it was noted that there was substantial bulk shielding around the supply air shaft. Subsequent discussions with EDF and AREVA indicated that the thickness of the shield walls for this area was driven by the requirement to reduce dose rates in adjacent rooms during post-accident conditions. I requested information on the radiation sources, shielding provisions and predicted dose rates during accident conditions in the supply air shaft in TQ-EPR-1502 (Ref. 16). The response to TQ-EPR-1502 (Ref. 16) from EDF and AREVA provided additional information on the supply air shaft which included the following.

- The source term for the supply air shaft was provided during Step 4 in response to TQ-EPR-592 (Refs 13 and 41).
- The shielding calculations showed that the thickness of concrete was sufficient to decrease the dose rate in the adjacent corridor to less than $1microSvh^{-1}$ (class A, "green zone", see Table 2).

Findings

159 In the opinion of the TSC, from the evidence provided, based on the predicted upper bound dose rates expected within the air supply shaft following an accident and shielding afforded by the surrounding walls, the review indicated that dose rates in adjacent areas should be acceptable to allow the required occupancy for preparation, maintenance and repair systems in the immediate vicinity during post-accident conditions. I concur with the TSC from the evidence provided on shielding provisions for the air supply shaft during post-accident conditions.

4.2.9.2 Safeguard Buildings - Radiological Protection

160 This Sub-section summarises the assessment and findings of radiological protection aspects of the Nuclear Auxiliary Building. During the assessment I raised TQ-EPR-1502 (Ref. 16) in consultation with the TSC, TUV SUD, to request further clarification relating to these radiological protection aspects.

Assessment

161 The calculated dose rates of all rooms in the Safeguard Building during power operation and during shut down were listed in the overview radiological zoning document (Ref. 20). The response to TQ-EPR-1502 (Ref. 16) from EDF and AREVA regarding rooms "For Special Use", RIS pump room and air supply shaft is summarised in Sub-sections 4.2.9.1.1, 4.2.9.1.2 and 4.2.9.1.3. In brief, the shielding provisions for these rooms were adequate. The RIS pump room had dual classification such that the room was class B ("yellow zone", see Table 2) during normal operation when access was required, and was class D ("orange zone, see table 2) during outages when access was not necessary.

162 The dual classification of the RIS pump room was not included in the floor plans of the overview radiological zoning document (Ref. 20), and this would be corrected in the next revision of the overview document (Ref. 21).

163 Expectations on radiological protection and designation of areas are in RP.3 of the SAPs (Ref. 2) and in the TAG on Radiological Protection (T/AST/038) (Ref. 3) (see Section 4.3.3). In particular, guidance on higher category zones for radiation, contamination and airborne activity being nested within less highly categorised zones are in paragraph 485 of the SAPs (Ref. 2), in paragraph 4.7 of the TAG on radiological protection (T/AST/038) (Ref. 3) and in paragraphs 4.1 and 4.12(4) of the TAG on ventilation (T/AST/022) (Ref. 3).

Findings

164 In my opinion, and in the opinion of the TSC, from the evidence provided, all high occupancy access areas, especially corridors, stairways and maintenance floors, were classed as "green" zones (see Table 2) which was consistent with requirements in IRR99 (Ref. 24) regarding restricting exposure SFAIRP and with relevant good practice in the best operating NPPs abroad.

165 In my opinion, and in the opinion of the TSC, from the evidence provided, there was no need to cross high dose rate areas in order to access rooms with lower dose rates within the Safeguard Buildings.

166 I have identified a GDA Assessment Finding during periods when high dose rates are present involving the RIS pump room in the Safeguard Buildings during normal operation and during primary system cool down as follows.

> ***AF-UKEPR-RP-21:*** *The future licensee shall provide ALARP justifications and procedures to provide engineering or administrative measures to restrict access of*

personnel into areas during periods when high dose rates are present. This shall include the following.

(a) See Sub-section 4.2.7.2.2.

(b) – (e) See Sub-section 4.2.8.2.1.

(f) The future licensee shall provide an ALARP justification for workers in the RIS pump room (HLF0102ZL) in the Safeguard Buildings during normal operation and during primary system cool down and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during normal operation and during primary system cool down, as necessary.

Required timescale: *This shall be completed before fuel on site.*

4.2.10 Revised Overview Radiological Zoning Document

167 EDF and AREVA reviewed their overview radiological zoning document (Ref. 20) to take account of comments made by ONR through TQs (TQ-EPR-1498 to TQ-EPR-1502) (Ref. 16), and submitted the revised overview radiological zoning document (Ref. 21).

168 I assessed the revised overview radiological zoning document (Ref. 21) against the responses from EDF and AREVA to the TQs raised (a full technical review of the overview radiological zoning document and its appendices was not repeated). I was supported in my assessment by the TSC, NT (Ref. 42). The purpose of the assessment was as follows.

- To ensure that comments raised and responses made in TQ-EPR-1498 to TQ-EPR-1502 (Ref. 16) were adequately incorporated into the revised report.
- To compare the tables against those in the previous report. In cases where radiological classifications or dose rates had changed, consideration was given to the potential impact of those changes.

169 The findings of the assessment of the revised overview radiological zoning document (Ref. 21) are summarised below (Ref. 42).

- EDF and AREVA had adequately updated the report in line with the responses given in TQ-EPR-1498 to TQ-EPR-1502 (Ref. 16). This included insertion of agreed text and reformatting of the tables.
- There were a number of instances where dose rates had been revised since the previous revision. However, this has generally resulted in a reduction in dose rates. In cases where the dose rates had increased, the dose rate had only increased marginally and did not require the radiological classification to be changed.
- In conclusion, the revised overview radiological zoning document (Ref. 21) was fit for purpose with regards to its technical content. Although there were some formatting problems within the document, these did not reduce the understanding of the reader.

170 The revised overview radiological zoning document (Ref. 21) was referenced in Sub-Chapter 12.3 of the updated consolidated PCSR (Ref. 22).

4.3 Comparison with Standards, Guidance and Relevant Good Practice

4.3.1 Legislation and guidance on radiological protection

171 Expectations regarding radiological protection are found in legislation and guidance.

172 The key pieces of legislation on the protection of workers and members of the public are IRR99 (Ref. 24), REPPIR (Ref. 25) and EPR10 (Ref. 26). The key pieces of associated guidance are the ACOP and guidance to IRR99 (Ref. 27) and guidance to REPPIR (Ref. 28).

4.3.2 Expectations on shielding

173 Expectations regarding shielding are found in legislation and associated guidance (see Section 4.3.1), in the SAPs (Ref. 2) and in the TAG on Shielding (T/AST/002) (Ref. 3).

- RP.6 of the SAPs on shielding (Ref. 2) expects that, where shielding has been identified as a means of restricting dose, it should be effective under all conditions (see Table 1).
- Paragraphs 493-495 of the SAPs (Ref. 2) provide guidance on RP.6 on shielding.
    - Paragraph 493 advises that, in particular, precautions should be taken so that the use of shielding and associated equipment takes account of and, where appropriate, reduces: a) the possible faults that may arise and changes of radiation types and levels during the lifetime of the facility, including any post-operational period prior to final decommissioning; b) the incidence of localised levels of radiation due to streaming; c) unplanned or uncontrolled movement or loss of shielding; d) installation behind shielding of components requiring regular handling or to which regular access is required, except where such components are sources of radiation requiring shielding; e) exposure of extremities of workers during handling and manipulation of radioactive sources; and f) unplanned or uncontrolled removal from behind shielding of any source.
    - Paragraph 494 advises that the use of shielding should be shown to be ALARP in that the dose saved by its use must exceed the dose received during its installation.
    - Paragraph 495 advises that where liquid is used as a shielding material, there should be design provisions for preventing unintentional loss of such liquid, suitable means should be provided for detecting such losses and initiating an alarm, and a recovery plan should be prepared and rehearsed.
- Paragraphs 2.12 and 4.12, parts of Section 4.5 and Appendix 1 of the TAG on Shielding (T/AST/002) (Ref. 3) provide guidance on shielding relevant to my assessment.
    - Paragraph 2.12 in Section 2 (Relationship to Licence and Other Relevant Legislation) advises that, in regulation 8 on restriction of exposure in IRR99 (Ref. 24), the restriction of exposure to ionising radiation should, wherever reasonably practicable, be achieved by engineering controls and design features, which could include shielding for normal operations and also for accidents.

- Paragraph 4.1.2 in Section 4.1 (Source Term Generation) advises that, in considering the validity of shielding calculations, ONR assessors should seek assurance that the source terms used are adequately and conservatively characterised in terms of isotopic mixture and activity levels, bearing in mind possible factors that could lead to the accumulation of activity, and the physical and chemical form of the source material.
- Paragraph 4.5.1 in Section 4.5 (Solid Shielding Materials) advises that shielding designs vary according to the nature of the ionising radiation presenting the hazard. In terms of solid shielding materials, concrete, steel and lead are frequently used for gamma rays, and polythene, jabroc and wood for neutrons. Guidance on shielding materials is given in Appendix 1.
- Paragraph 4.5.2 in Section 4.5 (Solid Shielding Materials) advises that the shielding design and the safety case should take account of the capability of materials to withstand the effects of foreseeable fault conditions. For example, high temperatures from a fire could cause lead shielding to melt or hydrogenous neutron shielding materials to burn. Failure of the shielding material in certain faults could lead to very high radiation fields. It is therefore important to ensure that the shielding materials used are fit for purpose.
- Paragraph 4.5.4 in Section 4.5 (Solid Shielding Materials) advises that ONR assessors may seek assurance from licensees that there are no degradation mechanisms, e.g. radiation damage, that will compromise the effectiveness of solid shielding materials as the facility ages.
- Appendix 1 (Shielding Materials) provides guidance to ONR assessors in considering the shielding materials in designs adopted in safety cases. This Appendix includes advice on steel, lead, lead glass, water, polythene, wood concrete, boral, jabroc, perspex and commercial materials for grouting.

4.3.3 Expectations on radiological protection and designated areas

174 Expectations regarding radiological protection and designated areas, and in particular on radiological zoning, are found in legislation and associated guidance (see Section 4.3.1), in the SAPs (Ref. 2), in the TAG on Radiological Protection (T/AST/038) (Ref. 3) and in the IAEA Safety Guide on Radiation Protection Aspects of Design for NPPs, NS-G-1.13 (Ref. 5). This guidance refers to external radiation, contamination and airborne activity, and these are often interlinked within the text in the guidance. As the GDA Issue dealt with radiological classification and bulk shielding, expectations relating to external radiation are relevant to this Assessment Report. Expectations relating to contamination and airborne activity are not relevant to this Assessment Report (see Section 4.2.1).

- RP.3 of the SAPs on designated areas (Ref. 2) expects that, where appropriate, designated areas should be further divided, with associated controls, to restrict exposure and prevent the spread of radioactive substances (see Table 1).
- Paragraphs 485-487 of the SAPs (Ref. 2) provide guidance on RP.3 on designated areas.
  - Paragraph 485 advises that further division of designated areas should be based upon the levels of radiation, contamination and airborne activity, measured and/or expected as the result of particular planned work activities.

- Paragraph 486 advises that each area should have appropriate controls on access and egress (including evacuation), occupancy and adequate arrangements for the use of personal protective equipment.
- Paragraph 487 advises that where doses of a significant fraction of any statutory dose limit are likely to be incurred in a matter of minutes in any area, access should be controlled by physical means such as interlocks, alarms, or locked doors to prevent unauthorised entry. Prompt escape by any person from such places should not be obstructed. Where such control measures are not reasonably practicable, an equivalent standard of protection should be ensured by other arrangements.

- Paragraphs 4.6 and 4.7 of the TAG on Radiological Protection (T/AST/038) (Ref. 3) provide guidance on designated areas relevant to my assessment.
  - Paragraph 4.6 advises that RP.3 indicates the need for controls in various areas of the facility commensurate with the radiation hazards in those areas. The area design requirements and access controls should always aim to keep exposures ALARP. The zone category should be an indication of the required degree of engineered and managerial controls and should increase, e.g. C1, C2, C3, etc. and R1, R2, R3, etc. for increasing levels of contamination and radiation, respectively. The safety case should make clear the zone categorisation, or area classification system, and corresponding protection arrangements.
  - Paragraph 4.7 advises that control of entry to the lowest category zone may be sufficient through the installation of physical barriers and warning signs whereas the controls in the highest zone may require segregation through shielding and mechanical interlocks (see paragraph 490 of SAPs (Ref. 2) for more detail). Access to the facility control room and other low-radiation areas with high occupancy should not require access through zones that would require substantial precautions. Higher category zones should be nested within the less highly categorised zones; for example, a higher contamination zone should be surrounded by or at least accessed by a lower contamination zone and the ventilation arrangements should ensure airflow is from lower to higher category zones (see T/AST/022 on Ventilation) (Ref. 3). The design layout should facilitate the radiation protection controls and restrict radiation exposure as far as is reasonably practicable. For example, components containing little or no radioactivity should, where feasible, be located outside areas where the radiation levels are high; components used in high radiation levels should be designed to be easily removable if maintenance is required and provision should be made, where necessary, to sample radioactive liquids in such a way as to minimise exposure and spread of contamination.

- The IAEA Safety Guide on Radiation Protection Aspects of Design for NPPs, NS-G-1.13 (Ref. 5), provides guidance on optimisation of radiation exposure within NPPs relevant to my assessment.
  - Paragraph 2.1 advises that consideration of the ALARA principle concerning dose rates within the NPP.

- Paragraph 2.2 advises that the design should ensure that no dose limits or dose constraints are exceeded.
- Paragraphs 2.4 and 3.5 advise that the optimisation and reduction of dose rates has to be undertaken not only throughout the design phase but also during all phases of the lifetime of equipment and installations.
- Paragraphs 2.7 and 2.8 advises that one of the key requirements of the IAEA Safety Guide is the concept of design targets which should be set for individual dose and collective dose, especially for groups of workers who are likely to receive the greatest doses.

4.4 Findings

4.4.1 Findings relating to shielding

175 My Step 4 assessment of the UK EPR™ included the review of radiation protection guidelines, radiological zoning guidance and shielding methodologies which gave reasonable confidence that the shielding provisions for the UK EPR™ would be able to meet UK requirements (Ref. 7). This was supported by the shielding assessment samples for the Reactor Building and Fuel Building which demonstrated how EDF and AREVA had consistently employed good shielding practices along with appropriate calculation methods during the design and optimisation of the shielding provisions (Ref. 7).

176 This Assessment Report summarises the supplementary assessment of the GDA Issue on radiological zoning and bulk shielding (GI-UKEPR-RP-01, Ref. 6) which included assessing shielding aspects of the overview radiological zoning document (Ref. 20), responses to TQ-EPR-1498 to TQ-EPR-1502 (Ref. 16), and the subsequent revised version of the overview radiological zoning document (Ref. 21).

177 In my opinion, from the evidence provided, EDF and AREVA has designed the plant to ensure that the general bulk shielding provisions and dose rate profile throughout the UK EPR™ are acceptable and consistent with UK design guidance and practices, and there is no reason why the bulk shielding design (associated with the civil structure) will not be able to achieve the dose rates outlined in the updated overview radiological zoning document (Ref. 21).

4.4.2 Findings relating to radiological protection

178 My Step 4 assessment of the UK EPR™ included the review of radiological protection which demonstrated that EDF and AREVA had designed the plant and its operations to ensure that engineered features would restrict exposures to workers and the public to ionising radiation so far as is reasonably practicable during normal operation and accidents conditions (Ref. 7).

179 This Assessment Report summarises the supplementary assessment of the GDA Issue on radiological zoning and bulk shielding (GI-UKEPR-RP-01, Ref. 6) which included assessing radiological protection aspects of the overview radiological zoning document (Ref. 20), responses to TQ-EPR-1498 to TQ-EPR-1502 (Ref. 16), and the subsequent revised version of the overview radiological zoning document (Ref. 21).

180 In my opinion, from the evidence provided, the radiological classification of rooms in the nuclear island of the UK EPR™ was consistent, well documented and complete, and was

consistent with relevant good practice and comparable to the best operating NPPs in the UK and abroad (Ref. 21).

181 ONR will in future need some additional detailed information to underpin my findings, but it is not appropriate to progress this at the current stage of design development. This has therefore been identified as an Assessment Finding on the provision of adequate ALARP justifications and engineering or administrative measures to restrict access of personnel to rooms with dual classification during periods when high dose rates are present (see Sub-sections 4.2.7.2.2, 4.2.8.2.1 and 4.2.9.2).

> ***AF-UKEPR-RP-21:*** *The future licensee shall provide ALARP justifications and procedures to provide engineering or administrative measures to restrict access of personnel into areas during period when high dose rates are present. This shall include the following.*
>
> *(a) The future licensee shall provide an ALARP justification for workers in the fuel loading hall (HK1015ZL) in the Fuel Building during the special case of fuel handling operations and shall provide procedures involving engineering or administrative measures to restrict access of workers to that hall during such fuel handling operations, as necessary.*
>
> *(b) The future licensee shall provide an ALARP justification for workers in the REN sampling box room (HNX0663ZL) in the Nuclear Auxiliary Building during the special case of resin flushing operations and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during such resin flushing operations, as necessary.*
>
> *(c) The future licensee shall provide an ALARP justification for workers in the valve room (HNX0670ZL) in the Nuclear Auxiliary Building during normal operation and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during normal operation, as necessary.*
>
> *(d) The future licensee shall prevent access of workers to the valve room (HNX0670ZL) in the Nuclear Auxiliary Building during the special case of resin flushing operations and shall provide procedures involving engineering or administrative measures to prevent access of workers to that room during such resin flushing operations, as necessary.*
>
> *(e) The future licensee shall provide an ALARP justification for workers in the storage room for low activity waste (HNX1794ZL) in the Nuclear Auxiliary Building during the special case of highly radioactive waste packages being stored in that room and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during such storage operations, as necessary.*
>
> *(f) The future licensee shall provide an ALARP justification for workers in the RIS pump room (HLF0102ZL) in the Safeguard Buildings during normal operation and during primary system cool down and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during normal operation and during primary*

system cool down, as necessary.

Required timescale: *This shall be completed before fuel on site.*

5 ASSESSMENT FINDINGS

182 There were 20 Assessment Findings in my Step 4 Radiological Protection Assessment Report (Ref. 7).

5.1 Additional Assessment Findings

183 I conclude that the additional Assessment Finding in Annex 1, AF-UKEPR-RP-21, should be programmed during the forward programme of this reactor as normal regulatory business.

5.2 Impacted Step 4 Assessment Findings

184 There are no impacted Step 4 Assessment Findings.

6 ASSESSMENT CONCLUSIONS

185 This Assessment Report presents the findings of the assessment of GDA Issue GI-UKEPR-RP-01 on radiological zoning and bulk shielding (Ref. 6).

6.1 Overall Conclusions

186 EDF and AREVA have submitted all the documentation committed within their Resolution Plan and have submitted all responses to Technical Queries. This information has been assessed by ONR and judged to provide an adequate response to the GDA Issue. On this basis, GDA Issue GI-UKEPR-RP-01 is now closed. There are no other GDA Issues associated with radiological protection.

187 In my opinion, from the evidence provided, EDF and AREVA have designed the plant to ensure that the general bulk shielding provisions and shielding provisions for the dose rate profile throughout the UK EPR™ are acceptable and consistent with UK design guidance and practices, and the radiological classification of rooms in the nuclear island of the UK EPR™ is consistent with relevant good practice and comparable to the best operating NPPs in the UK and abroad.

188 ONR will in future need some additional detailed information to underpin my findings, but it is not appropriate to progress this at the current stage of design development. This has therefore been identified as an Assessment Finding on the provision of adequate ALARP justifications and engineering or administrative measures to restrict access of personnel to rooms with dual classification during periods when high dose rates are present.

189 Overall, based on the sample undertaken in accordance with ONR procedures, I am satisfied that the additional information / documentation submitted to close-out the GDA Issue, which supports the claims, arguments and evidence already laid down within the PCSR and supporting documentation during Step 4 of the GDA process, present an adequate safety case for the generic UK EPR™ reactor design. I consider that from a radiological protection view point the EDF and AREVA UK EPR™ design is suitable for construction in the UK.

6.2 Review of the Update to the PCSR

190 The revised version of the overview radiological zoning document (Ref. 21) was referenced in Sub-chapter 12 of the updated consolidated PCSR (Ref. 22). This completed GDA Issue GI-UKEPR-RP-01 and GDA Issue Action GI-UKEPR-RP-01.A1.

7 REFERENCES

1 *ONR HOW2. Permissioning - Purpose and Scope of Permissioning.* PI/FWD, Issue 3. HSE. August 2011.

2 *Safety Assessment Principles for Nuclear Facilities.* 2006 Edition Revision 1. HSE. January 2008. www.hse.gov.uk/nuclear/SAP/SAP2006.pdf.

3 *Radiation Shielding.* T/AST/002 Issue 3. HSE. March 2009.
Ventilation. T/AST/022 Issue 1. HSE. June 2000.
Radiological Protection. T/AST/038 Issue 2. HSE. June 2009.
www.hse.gov.uk/nuclear/operational/tech_asst_guides/index.htm.

4 *Western European Nuclear Regulators' Association. Reactor Harmonization Group. WENRA Reactor Reference Safety Levels.* WENRA. January 2008. www.wenra.org.

5 *Safety of Nuclear Power Plants: Design. Safety Requirements.* Safety Standard No. NS-R-1. International Atomic Energy Agency (IAEA). 2000.
Radiation Protection Aspects of Design for Nuclear Power Plants. Safety Guide No. NS-G-1.13. International Atomic Energy Agency (IAEA). 2005.
www.iaea.org.

6 *GDA Issue GI-UKEPR-RP-01 Revision 0. Radiological Zoning and Bulk Shielding.* ONR. July 2011. TRIM Ref. 2011/385314.

7 *Step 4 Radiological Protection Assessment of the EDF and AREVA UK EPR™ Reactor*. ONR Assessment Report ONR-GDA-AR-11-025 Revision 0. TRIM Ref. 2010/581507.

8 *Resolution Plan for GDA Issue GI-UKEPR-RP-01-RP Revision 0.* EDF and AREVA. June 2011. TRIM Ref. 2011/352056.

9 *Reference Design Configuration*. UKEPR-I-002 Revision 13. UK EPR. September 2012. TRIM Ref. 2012/350053.

10 *Design Change Procedure.* UKEPR-I-003 Revision 9. EDF and AREVA. June 2012. TRIM Ref. 2012/243501.

11 *UK EPR Pre-construction Safety Report – November 2009 Submission.* Submitted under cover of EDF and AREVA letter UN REG EPR00226N. 30 November 2009. TRIM Ref. 2009/481363 and as detailed in UK EPR Submission Master List. November 2009. TRIM Ref. 2011/46364.

12 *UK EPR GDA Step 4 Consolidated Pre-construction Safety Report – March 2011.* EDF and AREVA. Submitted under cover of EDF and AREVA letter UN REG EPR00997N. 18 November 2011. TRIM Ref. 2011/552663.

13 *EDF and AREVA UK EPR™ - Schedule of Technical Queries Raised during GDA Step 1 to Step 4.* HSE-ND. TRIM Ref. 2010/600726.

14 *EDF and AREVA UK EPR™ - Schedule of Regulatory Observations Raised during GDA Step 1 to Step 4.* HSE-ND. TRIM Ref. 2010/600727.

15 Not used.

16 *EDF and AREVA UK EPR™ - Schedule of Technical Queries Raised during GDA Close-out.* Office for Nuclear Regulation. TRIM Ref. 2011/389411.

17 *Closure of GDA for the EPR: Assessment Plan for Radiological Protection.* Revision E. October 2011. TRIM Ref. 2011/540156.

18 *GDA Shielding Review of the Radiological Zoning for the EDF/AREVA EPR Reactor Design.* NT/722500565/R1001 (GDA0081/SH01/R01) Revision 0. Nuclear Technologies. March 2012. TRIM Ref. 2012/196470.

19 *GDA Radiation Protection Review for the Radiological Zoning of the EDF/AREVA Reactor Design.* IS/ETS3-4-2012 Revision 0. TUV SUD. March 2012. TRIM Ref. 2012/196506.

20 *UK EPR – Overview of the Radiological Zoning of the Nuclear Island.* ECEIG111267, Revision A. EDF. July 2011. TRIM Refs 2011/413259, 2012/355916, 2012/355919, 2012/355922, 2012/355923.

21 *UK EPR – Overview of the Radiological Zoning of the Nuclear Island.* ECEIG111267, Revision B. EDF. March 2012. TRIM Refs 2012/130831, 2012/130844, 2012/130854, 2012/130862, 2012/130868.

22 *UK EPR GDA Step 4 Consolidated Pre-construction Safety Report, Sub-chapter 12.3. UKEPR-0002-123-I04 - June 2012.* EDF and AREVA. TRIM Ref. 2012/260155. Submitted under cover of EDF and AREVA letter UN REG EPR01222N. 29 June 2012. TRIM Ref. 2012/260153.

23 *Occupational Radiological Protection Principles and Criteria for designing New Nuclear Power Plants.* NEA No. 6975. Nuclear Energy Agency: Organisation for Economic Co-operation and Development. 2010. www.oecd-nea.org.

24 *Ionising Radiations Regulations 1999.* Statutory Instrument No. 3232. 1999.

25 *Radiation (Emergency Preparedness and Public Information) Regulations 2001.* Statutory Instrument No. 2975. 2001.

26 *Environmental Permitting (England and Wales) Regulations 2010, as amended.* Statutory Instrument No. 675. 2010.

27 *Work with Ionising Radiation: Ionising Radiations Regulations 1999: Approved Code of Practice and Guidance.* L121. HSE Books. 2000. ISBN: 978 0 7176 1746 3.

28 *A Guide to the Radiation (Emergency Preparedness and Public Information) Regulations 2001. REPPIR.* L126. HSE Books. 2002. ISBN: 978 0 7176 2240 5.

29 *Step 3 Radiological Protection Assessment of the EDF and AREVA UK EPR.* HSE-ND Assessment Report AR 09/030. November 2009. TRIM Ref. 2009/335834.

30 *GDA Step 4 Radiological Protection Assessment Plan for the EDF and AREVA UK EPR.* HSE-ND Assessment Plan AR 09/052, January 2010, TRIM Ref. 2009/462102.

31 *GDA Shielding Review for the EDF/AREVA EPR Reactor Design.* NT/722500565/R850 (GDA00653/SH01/R01) Revision 0. Nuclear Technologies. February 2011. TRIM Ref. 2011/122452.

32 *EPR FA3 Radiation Protection Guidelines.* ECEIG051117 Revision B. EDF. May 2007. TRIM Ref. 2011/121733.

33 *Methodology to Calculate Dose Rate for Rooms Classification.* EYRL2008fr00018, Khamakhen Baumann, July 2008. TRIM 2011/156098.

34 *Collection of Requirements and Elements of Methodology for the Realisation of the Studies of Radiation Protection Zoning FA3.* ECEIG061049 Revision B1. EDF. March 2010. TRIM Ref. 2011/92109.

35 *Modelling hypotheses and input data for calculating dose rates in the EPR-FA3 reactor building.* ECEIG092367 Revision A1. EDF. June 2010. TRIM Ref. 2011/92757.

36 *Radiological Classification of Priority Rooms in the Fuel Building: Level -9.60m.* EYRL2009fr0054 Revision B1. Sofinel. October 2009. TRIM Ref. 2011/92772.

37 *GDA Radiation Protection Review for the EDF/AREVA EPR Reactor Design.* IS/ETS3-3-2011 Revision 0. TUV SUD. June 2011. TRIM Ref. 2011/426229.

38 *RO-UKEPR-73.A1 – Source term.* Letter from EDF AREVA Project Front Office to ND. EPR00554N. 2 September 2010. TRIM Ref. 2010/385939.

39 *EPR: Activity Concentrations in the TEP, REA, TEG, RPE, TEU and TES Auxiliary Systems.* ENTERP070291 Revision A. EDF AREVA. November 2007. TRIM Ref. 2011/92969.

40 *EPR FA3 – Specific Activity Concentrations of Nuclides in Reactor Building Systems.* NEEM-FDC30 Revision F. AREVA. December 2007. TRIM Ref. 2011/92987.

41 *Accessibility to SABs, FB in Post-Accident Conditions (SA and PCC4 LB-LOCA) in the long term phase.* ECEIG101497, Revision A1, EDF, March 2011. TRIM Ref. 2011/212372.

42 *Review of Revised Radiological Zoning for EPR* (ECEIG1111267 Revision B). NT Letter GDA00881-EPR-M03. 29 May 2012. TRIM Ref. 2012/236418.

Table 1

Relevant Safety Assessment Principles Considered for Close-out of GI-UKEPR-RP-01 Revision 0

SAP No.	SAP Title	Description
RP.3	Radiation Protection: Designated Areas	**Where appropriate, designated areas should be further divided, with associated controls, to restrict exposure and prevent the spread of radioactive substances.** The further division of designated areas should be based upon the levels of radiation, contamination and airborne activity, measured and/or expected as the result of particular planned work activities. Each area should have appropriate controls on access and egress (including evacuation), occupancy and adequate arrangements for the use of personal protective equipment. Where doses of a significant fraction of any statutory dose limit are likely to be incurred in a matter of minutes in any area, access should be controlled by physical means such as interlocks, alarms, or locked doors to prevent unauthorised entry. Prompt escape by any person from such places should not be obstructed. Where such control measures are not reasonably practicable, an equivalent standard of protection should be ensured by other arrangements.

Table 1

Relevant Safety Assessment Principles Considered for Close-out of GI-UKEPR-RP-01 Revision 0

SAP No.	SAP Title	Description
RP.6	Radiation Protection: Shielding	**Where shielding has been identified as a means of restricting dose, it should be effective under all conditions.** In particular, precautions should be taken so that the use of shielding and associated equipment takes account of and, where appropriate, reduces: a) the possible faults that may arise and changes of radiation types and levels during the lifetime of the facility, including any post-operational period prior to final decommissioning; b) the incidence of localised levels of radiation due to streaming; c) unplanned or uncontrolled movement or loss of shielding; d) installation behind shielding of components requiring regular handling or to which regular access is required, except where such components are sources of radiation requiring shielding; e) exposure of extremities of workers during handling and manipulation of radioactive sources; and f) unplanned or uncontrolled removal from behind shielding of any source. The use of shielding should be shown to be ALARP in that the dose saved by its use must exceed the dose received during its installation. Where liquid is used as a shielding material, there should be design provisions for preventing unintentional loss of such liquid, suitable means should be provided for detecting such losses and initiating an alarm, and a recovery plan should be prepared and rehearsed.

…

Table 2

UK EPR™ Radiological Classification

Classification	*Dose Rate limit*	*Zoning*
Outside monitored and controlled areas		
0.08 mSv/month		
MONITORED AREA		
7,5 µSv/h		
CONTROLLED AREA		
A	10 µSv/h	Green zone *Regulated Work Area*
2,5A	25 µSv/h	
B	0,1 mSv/h	Yellow zone *Regulated Stay Area*
2B	0,2 mSv/h	
C	1 mSv/h	
2C	2 mSv/h	
D	10 mSv/h	Orange zone *Limited Stay Area*
3D	30 mSv/h	
E	0,1 Sv/h	
3E	0,3 Sv/h	Red zone *Prohibited Area*
F	1 Sv/h	
3F	3 Sv/h	
G	10 Sv/h	
3G	30 Sv/h	
H	100 Sv/h	
3H	300 Sv/h	
I	1000 Sv/h	
3I	3000 Sv/h	
K	10000 Sv/h	

Annex 1

GDA Assessment Finding Arising from GDA Close-out for Radiological Protection
GDA Issue GI-UKEPR-RP-01 Revision 0

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UKEPR-RP-21	The future licensee shall provide ALARP justifications and procedures to provide engineering or administrative measures to restrict access of personnel into areas during periods when high dose rates are present. This shall include the following.	This shall be completed before fuel on site.
	(a) The future licensee shall provide an ALARP justification for workers in the fuel loading hall (HK1015ZL) in the Fuel Building during the special case of fuel handling operations and shall provide procedures involving engineering or administrative measures to restrict access of workers to that hall during such fuel handling operations, as necessary.	
	(b) The future licensee shall provide an ALARP justification for workers in the REN sampling box room (HNX0663ZL) in the Nuclear Auxiliary Building during the special case of resin flushing operations and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during such resin flushing operations, as necessary.	
	(c) The future licensee shall provide an ALARP justification for workers in the valve room (HNX0670ZL) in the Nuclear Auxiliary Building during normal operation and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during normal operation, as necessary.	
	(d) The future licensee shall prevent access of workers to the valve room (HNX0670ZL) in the Nuclear Auxiliary Building during the special case of resin flushing operations and shall provide procedures involving engineering or administrative measures to prevent access of workers to that room during such resin flushing operations, as necessary.	

Annex 1

GDA Assessment Finding Arising from GDA Close-out for Radiological Protection
GDA Issue GI-UKEPR-RP-01 Revision 0

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
	(e) The future licensee shall provide an ALARP justification for workers in the storage room for low activity waste (HNX1794ZL) in the Nuclear Auxiliary Building during the special case of highly radioactive waste packages being stored in that room and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during such storage operations, as necessary.	
	(f) The future licensee shall provide an ALARP justification for workers in the RIS pump room (HLF0102ZL) in the Safeguard Buildings during normal operation and during primary system cool down and shall provide procedures involving engineering or administrative measures to restrict access of workers to that room during normal operation and during primary system cool down, as necessary.	

Note: It is the responsibility of the Licensees / Operators to have adequate arrangements to address the Assessment Findings. Future Licensees / Operators can adopt alternative means to those indicated in the findings which give an equivalent level of safety.

For Assessment Findings relevant to the operational phase of the reactor, the Licensees / Operators must adequately address the findings during the operational phase. For other Assessment Findings, it is the regulators' expectation that the findings are adequately addressed no later than the milestones indicated above.

Annex 2

GDA Issue, GI-UKEPR-RP-01 – Radiological Protection – UK EPR™

EDF AND AREVA UK EPR GENERIC DESIGN ASSESSMENT
GDA ISSUE
RADIOLOGICAL ZONING AND BULK SHIELDING
GI-UKEPR-RP-01 REVISION 0

Technical Area	**RADIATION PROTECTION**		
Related Technical Areas	Civil Engineering		
GDA Issue Reference	**GI-UKEPR-RP-01**	**GDA Issue Action Reference**	**GI-UKEPR-RP-01.A1**
GDA Issue	Radiological zoning for restriction of exposure to ionising radiation of workers is fundamental to the design of the nuclear island, and bulk shielding is inextricably linked with civil engineering aspects of that design. The radiological zoning classification scheme underpinned by design shielding calculations is not referenced in the GDA submission for the UK EPR design.		
GDA Issue Action	Provide an overview document that supplements the claims and arguments presented in the PCSR Chapter 12.3 with additional information on the radiological zoning classification scheme for the nuclear island, including dose rate criteria and predictions for all modes of plant operation, for occupied areas as a direct reference from the PCSR. A radiological zoning classification scheme should be provided to demonstrate that there is adequate shielding provision for all areas of the facility. This should be presented as an overview document that provides information / documentation which summarises the dose rates and radiological classifications within all rooms and for all modes of plant operation (for example, power operation, outages, refuelling). The document should include information / documentation on the Reactor Building, Fuel Building, Safeguard Building, and Auxiliary Building. The overview document should summarise the results of shielding calculations to show that the predicted dose rates within each area of the plant meet the radiological classification. The response should, as a minimum, summarise the following information for each room of the facility: • Room descriptor and number / designation. • Radiological classification (namely dose rate criteria). • Dose rate prediction(s) for each room giving the maximum dose rate present during all modes of operation (for example, power operation, outages, refuelling). • Reference to shielding assessments / calculations containing data regarding the assumed radiation sources, shielding provisions and calculated dose rates. With agreement from the Regulator this action may be completed by alternative means.		