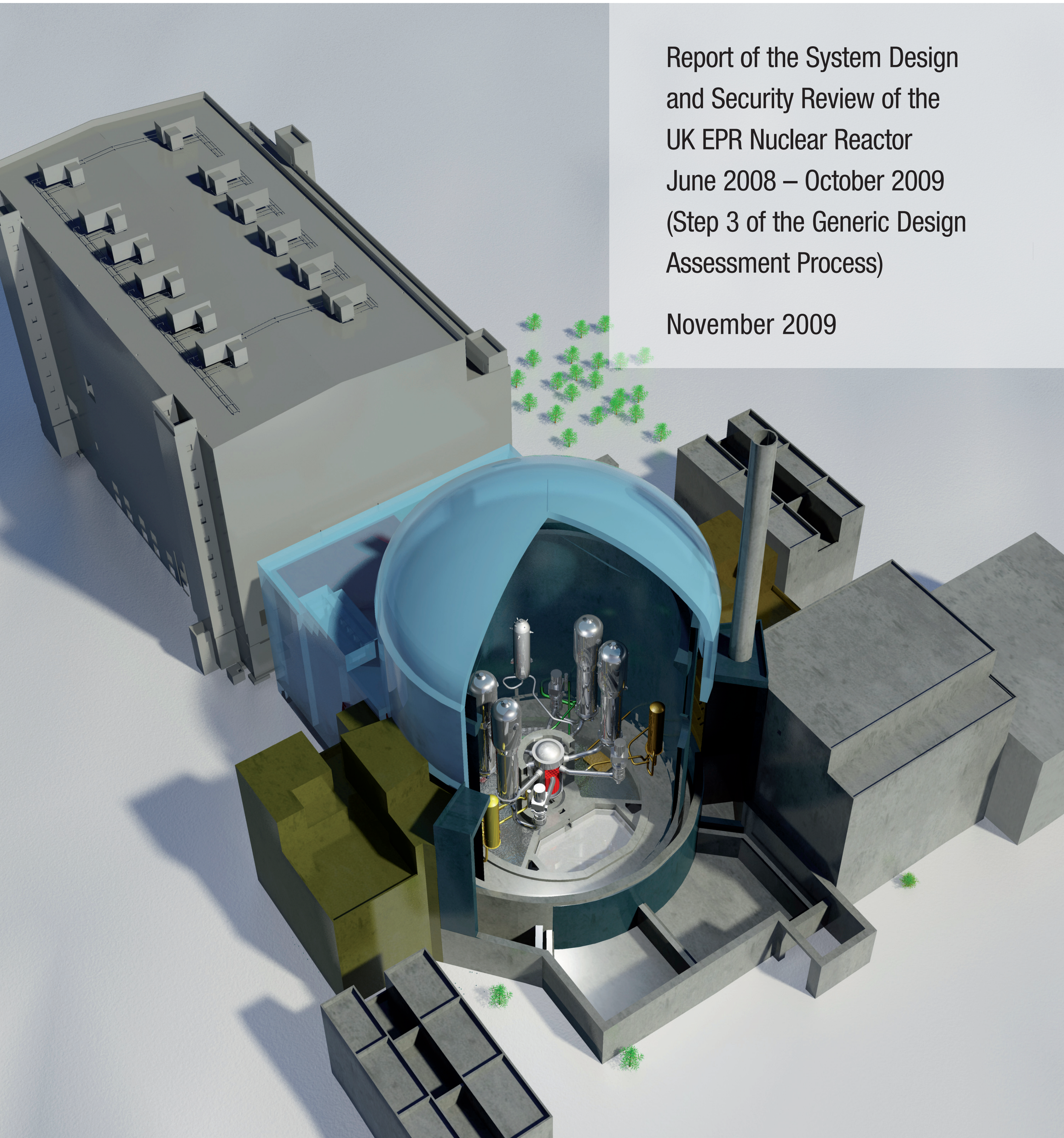
Health and Safety Executive

# Public Report on the Generic Design Assessment of New Nuclear Reactor Designs

## AREVA NP SAS and EDF SA UK EPR Nuclear Reactor

Report of the System Design and Security Review of the UK EPR Nuclear Reactor
June 2008 – October 2009
(Step 3 of the Generic Design Assessment Process)

November 2009



# Contents

# Foreword

I am pleased to present in this Generic Design Assessment (GDA) Step 3 report the developing findings of our assessment of the UK European Pressurised-water Reactor, the UK EPR. This is in effect akin to a mid-point progress report on how our assessment is progressing through the GDA process that we started in 2007 and are planning to complete in mid 2011. We publish this report today, together with a series of more detailed supporting technical reports, as part of our commitment to be open and transparent about our work on GDA.

This current project is the first application of GDA, which is a new process for both us and the industry. GDA seeks to get the Nuclear Regulators involved at an early stage in the development of proposals for new nuclear power stations and it allows the technical assessments of the reactors to be conducted before any specific nuclear site licence assessments are undertaken. In this way we are seeking to identify and address any potential regulatory questions and challenges before commitments are made to construct the reactors. We believe that we are being successful in this aim as is evidenced by the contents of this report.

The GDA assessment is in several steps and includes initial and then more detailed examinations of the safety and security of the proposed reactors. We are undertaking our GDA assessment jointly with the Environment Agency and in parallel with our work on safety and security aspects, the Environment Agency is examining the potential environmental impact. The step-wise assessment approach was planned to allow us to look in increasing detail at the safety and security issues as we progress through the various Steps, and also it allowed us to start with a fairly small assessment team and to grow this as we progressed through the project. After a slow start we have made excellent progress in deploying more resource, and we have also set-up a technical support framework within which we have placed over 40 support contracts to further bolster the analytical resources available to us. The result of this has been that, whilst our GDA programme suffered some delay against the original plan during 2008, over the last year there has been an acceleration in our technical work and I am therefore confident in our assessment plan for the remainder of GDA.

We published a set of reports on the outcome of GDA Step 2, the initial assessment, in March 2008. More recently, we have reported on our progress through a series of Quarterly Reports. These are available on our website. This report, that we are publishing today, is on the subject of our GDA Step 3 assessment, the overall design safety and security review, and it covers the period from June 2008 to the end of October 2009. In some areas we did not have sufficient resource in place at the beginning of GDA Step 3, in others, we have had insufficient information from EDF and AREVA, and this has limited the extent of assessment sampling that we have been able to do. In this report, we have identified where this has been the case and where we intend to significantly accelerate our assessment during GDA Step 4.

As is normal for complex assessment projects of this type, we are identifying technical questions and issues that we are requesting EDF and AREVA to address. They are making progress in doing so, but at this stage, as we are only part way through GDA, many remain open and require further work. We have identified the more significant of the issues within this report, and we anticipate that progress on them will continue through Step 4 of GDA, the detailed design assessment. This will require an ongoing active dialogue with additional detailed assessment by us, and high quality and timely safety submissions from EDF and AREVA. The fact that we have identified these issues should not in all cases be interpreted as us being critical of the UK EPR design, rather, they should be seen as evidence of an independent and robust regulatory process. They are also evidence that GDA is working as intended and allowing us to have influence on the design and safety case well in advance of construction in the UK.

If you have any comments on this report I will be pleased to hear from you. To assist in this we have extended the existing GDA public involvement process to invite comments on any of our GDA Step 3 reports.

**Kevin Allars**
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**Nuclear Directorate**
**Health and Safety Executive**

# Executive summary

This is an interim report on the Health and Safety Executive's (HSE) GDA work and it summarises our findings to date.

This report is the second of our major public reports for the UK EPR and it covers our GDA Step 3 work. The aim of GDA Step 3 was to provide an overall design safety and security review of the EPR, and specifically to:

- improve our knowledge of the design;
- identify significant issues;
- identify whether any significant design or safety case changes may be needed;
- identify major issues that may affect design acceptance and attempt to resolve them; and
- achieve a significant reduction in regulatory uncertainty. (By this we mean that we are seeking to identify and address any potential regulatory questions and challenges before commitments are made to construct the EPR in the UK).

A further aim for GDA Step 3 was that it would allow HSE inspectors to further familiarise themselves with the design and safety case and provide a basis for planning subsequent assessment work.

To achieve these aims, HSE's Nuclear Directorate has undertaken an examination of the UK EPR at the system level and analysed EDF and AREVA's supporting arguments. From a security perspective, the foundations for developing the conceptual security plan have been laid through dialogue with EDF and AREVA.

The summary of our assessment is given in this report. We continue to believe that the UK EPR could be suitable for construction on licensed sites in the UK. However, we have identified a significant number of issues with the safety features of the design that would first have to be progressed. If these are not progressed satisfactorily then we would not issue a 'Design Acceptance Confirmation' at the end of GDA Step 4.

We have raised significant concerns about the proposed architecture of the Control and Instrumentation (C&I) systems and we have asked EDF and AREVA to address these by making design modifications. They have agreed to do so and their initial proposals look reasonable.

Also, as part of our assessment of internal hazards, we have requested improved arrangements for ensuring the integrity of hazard barriers through implementation of door control measures. EDF and AREVA have agreed to make such a change and are planning to implement this through a design modification.

In both the above topic areas, we have yet to see the design modification details and so it is not yet possible for us to conclude on the acceptability of them.

For the other issues we have raised, it is too early to say whether they can be resolved solely with additional safety case changes or whether they may result in design modifications being necessary.

We will progress our assessment of these issues, in dialogue with EDF and AREVA during GDA Step 4. We will summarise our progress on these in our Quarterly Reports, which we will continue to place on our website, and in a final GDA report at the end of GDA Step 4 which is presently scheduled for June 2011.

# Background

The safety of nuclear installations is achieved by good design and operation, but it is assured by a system of regulatory control at the heart of which is the nuclear site licensing process. This requires a licence to be granted before any significant construction work can start (defined as: the placement of the first structural concrete for buildings with nuclear safety significance). The licence is granted, after assessment of the application, to a corporate body (eg an operator) to use a site for specified activities. In doing this we also look at the siting and organisational factors. Licensing and the licence conditions apply throughout the lifetime of an installation from manufacture, through construction, commissioning, operation, modification and on to eventual decommissioning.

In response to growing interest in nuclear power and in anticipation of possible applications for new build in the UK, the Nuclear Regulators (HSE and the Environment Agency) developed revised assessment proposals for new nuclear power stations and this led to the production of guidance on the GDA process, which was originally published in January 2007.[1]

The updated arrangements are based on a two-phase process which separates the GDA from the site-specific HSE licensing assessment and Environment Agency permitting process.

Phase 1, GDA, is a review of the safety features and acceptability of the proposed nuclear reactor design. It is undertaken independently from any specific site. The process will allow a rigorous and structured examination of detailed safety and security aspects of the reactor designs.

GDA consists of four steps.

- GDA Step 1 is the preparatory part of the design assessment process. It involves discussions between the Requesting Party and HSE to ensure a full understanding of the requirements and processes that would be applied, and to arrive at formal agreements to allow HSE to recover its costs from the Requesting Party.
- GDA Step 2 is an overview of the fundamental acceptability of the proposed reactor design concept within the UK regulatory regime. The aim is to identify any fundamental design aspects or safety shortfalls that could prevent the proposed design from being accepted for construction in the UK.
- GDA Step 3 is a system design safety and security review of the proposed reactor. The general intention is to move from considering the fundamental safety claims of the previous step to an analysis of the design, primarily by examination at the system level and analysing the supporting arguments made by the Requesting Party. From a security perspective, the foundations for developing the conceptual security plan are laid through dialogue with the Requesting Party.
- GDA Step 4 is designed to move from the system-level assessment of GDA Step 3 to a detailed examination of the evidence provided within the safety analyses, on a sampling basis. It will also seek to examine the proposed conceptual security plan. If the generic design is considered acceptable, we would issue a 'Design Acceptance Confirmation' at the end of GDA Step 4

Guidance on the GDA process is provided in *Nuclear power station generic design assessment – Guidance to Requesting Parties*[1] *and Guidance document for generic design assessment activities.*[2]

Therefore, in Phase 2, HSE will first carry out a site licence assessment, in which we will examine the proposed site, the management organisation of the operating company, and the proposed type of facility to be installed on the site. If the application is judged to be acceptable, we will grant a Nuclear site licence. More information on the licensing process can be found in the HSE publication *The Licensing of Nuclear Installations*.[3]

The intention is that the 'Design Acceptance Confirmation' would be carried forward from GDA to support the Phase 2 site-specific work and, in particular, HSE's assessment of whether to permit construction. It is our intention that there will be no reassessment of aspects included in the 'Design Acceptance Confirmation' except, of course, to address any Exclusions, new developments, site-specific elements, or any design changes proposed by the operator.

The 'Design Acceptance Confirmation' will therefore be required before permission to construct can be issued, but not necessarily before a site licence is granted. Ultimately the 'Design Acceptance Confirmation' can be used to underpin the permissions to construct a fleet of identical reactors, except for site or operator specific changes.

HSE considers that the GDA approach not only offers benefits to an expanding nuclear industry, but also strengthens HSE's position as an independent regulator with a focus on protecting workers, the public and society, by ensuring that it has sufficient time to address regulatory and technical issues relating to a design in advance of any significant construction activity.

Progress through GDA does not guarantee that any of the designs will eventually be constructed in the UK. What it does do is allow us to examine the safety and security aspects at an early stage where we can have significant influence, and to make public, reports about our opinions so that:

- the public can be informed about our independent review of the designs; and
- industry can have clarity on our opinions and thus take due account of them in developing new construction projects.

A further advantage of the GDA process is that it has been designed to allow the Nuclear Regulators to work closely together. In support of this we have set up a Joint Programme Office, which administers the GDA process on behalf of both Regulators, providing a 'one-stop-shop' for the assessment of potential new nuclear power stations. We believe this is improving efficiency both for the Nuclear Regulators and the Requesting Parties, and it helps to provide more effective regulation of potential hazards.

Following on from its Energy Review, the Government published an Energy White Paper in May 2007 (see www.decc.gov.uk), and at the same time, DTI (now the Department of Energy and Climate Change (DECC) invited interested parties to submit proposals to the Nuclear Regulators for reactor designs to be subject to GDA. In the event, four designs were proposed.

- ACR-1000 (Atomic Energy of Canada Limited).
- AP1000 (Westinghouse).
- ESBWR (GE-Hitachi).
- UK EPR (EDF and AREVA).

Based on DTI's advice that there was potential support from industry for building these four designs, HSE and the Environment Agency formally started a dialogue with each 'Requesting Party' and launched GDA in July 2007.

In April 2008 Atomic Energy of Canada Limited withdrew the ACR1000 from GDA and in June 2008 we made a statement on our website that GDA Step 3 was commencing for the remaining three designs.

In September 2008, GE-Hitachi requested that assessment work on the ESBWR be suspended and we therefore continued to progress GDA Step 3 on the UK EPR and AP1000 reactor designs only.

To ensure that people and society are properly protected, HSE will continue to apply the GDA process to the designs which are most likely to be chosen for construction in the UK. In allocating resources to this ongoing GDA process, HSE will therefore take due account of advice from the Government and others about the designs that are considered most likely to be progressed for construction.

This new GDA process is being conducted in an open and transparent way. We have made information about our process and the reactor designs available to the public via our website www.hse.gov.uk/newreactors. Furthermore, the public have been encouraged to comment on the reactor designs and we are considering these comments, along with the responses from the designers, within our assessment.

# Introduction

The role of the HSE's Nuclear Directorate is to protect people and society from the hazards of the nuclear industry. To achieve this aim in the light of proposals for construction of new nuclear power stations we have been assessing the nuclear safety and security aspects of two reactor[1] designs. We are examining these particular designs as they have been identified by DECC, as those most likely to be built in the UK, and which could therefore present a potential hazard to the public.

We launched GDA in July 2007. GDA Step 1 was devoted to preparatory work and was completed in August 2007. GDA Step 2, the fundamental safety overview was completed in March 2008 and we published a series of reports summarising our work and concluding that we had found no safety shortfalls that would rule out eventual construction of these reactors on licensed sites in the UK.[4]

This report is on the subject of GDA Step 3 of our assessment of the UK EPR, the overall design safety review, and it covers the period from June 2008 to end of October 2009. The aim of GDA Step 3 was to provide an overall design safety and security review of each design submitted and in this case the UK EPR, and specifically to:

- improve our knowledge of the design;
- identify significant issues;
- identify whether any significant design or safety case changes may be needed;
- identify major issues that may affect design acceptance and attempt to resolve them; and
- achieve a significant reduction in regulatory uncertainty.

It was also intended that GDA Step 3 would allow HSE inspectors to further familiarise themselves with the design and safety case and provide a basis for planning subsequent assessment work.

To achieve these aims, HSE has undertaken an examination of the UK EPR at the system level and analysed EDF and AREVA's supporting arguments. From a security perspective, the foundations for developing the conceptual security plan have been laid through dialogue with EDF and AREVA.

[1] In this report, the word 'reactor' can be taken to cover all nuclear safety and security related areas of the proposed nuclear power station design including radioactive waste and spent fuel storage facilities.

In this report, we describe the work we have completed, the safety issues that have emerged, and we give a summary of our assessment findings. To help manage our work, we have split it into 15 technical topic areas and our progress in each of these is summarised below. There are some additional introductory sections to help put our work into context and there are some additional summary sections (that do not fit easily into the 15 technical topic areas) which describe other activities, such as our work with overseas regulators, and on public involvement.

This report is intended to inform the public of our work on GDA and we believe it provides a comprehensive overview of our assessment to date. Further details can be found in the detailed supporting technical reports which have also been published via our website: www.hse.gov.uk/newreactors.

# HSE expectations for modern reactors

HSE will require any nuclear reactor that is built in the UK in the near future to be of a robust design that provides adequate protection against potential accidents to a degree that meets modern international good practice. In other words, reactors built in the UK should be as safe as modern reactors anywhere else in the world.

Potential accidents in a reactor could arise from failures of equipment, for example pipe leaks or pump breakdowns, or from hazards such as fires, floods, extreme winds, earthquakes, or aircraft crash. HSE expects the reactor to be designed to remain safe under all these scenarios. We expect to see a robust demonstration of three key features: the ability to shutdown the reactor and stop the nuclear chain reaction; the ability to cool the shutdown reactor; and the ability to contain radioactivity.

The adequacy of protection provided should be demonstrated by a comprehensive safety analysis that examines all the faults and hazards that could threaten the reactor. This should show that the reactor design is sufficiently robust to tolerate these faults and hazards and that it operates with large margins of safety. HSE expects an approach of defence-in-depth to be adopted. This means that if one part of the plant fails then another part is available to fulfil the same safety duty. To maximise protection, different backup systems and other safety features can be provided. This multi-barrier protection concept should be repeated until the risk of an accident is acceptably low.

In modern reactor design, these concepts are well understood and HSE therefore expects to see a comprehensive demonstration that an acceptably low level of risk has been achieved. The principles used by HSE in assessing whether the safety demonstration is adequate are set out in the document *Safety assessment principles for nuclear facilities*[5] (SAPs). To help ensure HSE applies good international practice in its assessment, the SAPs[5] were revised and updated in 2006 and this included benchmarking against the International Atomic Energy Agency (IAEA) Safety Standards.

# HSE expectations from the GDA process

Details of HSE's expectations for the GDA process as a whole, and specifically for Step 3 of the GDA process, can be found in the GDA guidance.[1] For the completeness of this report a key section of that document, which describes what HSE expects from a Requesting Party for GDA Step 3, is summarised in Annex 1.

Details of the expectations of the Office for Civil Nuclear Security (OCNS), which is a part of HSE, for GDA Step 2 can be found in the OCNS guidance.[2] In summary, the expectation is that a Requesting Party would provide sufficient information to allow an initial review of design submissions to enable OCNS to become familiar with the technology, and to form a view of the measures required to deliver appropriate security.

A key aim of this report is to provide a summary of the assessment of the information HSE has gathered from EDF and AREVA during GDA Step 3 to address the points listed in Annex 1.

## The safety standards and criteria used

The main document used for the GDA Step 3 assessment was the 2006 edition of HSE's *Safety assessment principles for nuclear facilities*[5] (SAPs). For radiological protection we also considered the requirements of the *Ionising Radiations Regulations 1999* (IRR99) and the Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR2001).

## Assessment strategy

The aim of GDA Step 3 was to provide an overall design safety and security review of each design and this report covers our assessment of the UK EPR. We have focused on an examination of the UK EPR at the system level and analysed EDF and AREVA's safety arguments. Our objective was to ensure that the arguments that supported the safety claims were complete and that they were reasonable in the light of our current understanding of reactor technology. Examination of the detailed evidence to support these arguments will come in our assessment during GDA Step 4.

As we apply a sampling approach to assessment, there were some technical topic areas which were not significantly covered by our GDA Step 2 assessment. Therefore for GDA Step 3 in these areas we focussed firstly on the claims and then considered the arguments supporting those claims.

In our GDA Step 3 assessment, we have made a judgement on the claims and arguments as presented in EDF and AREVA's UK EPR Pre-construction Safety Report (PCSR).[6] We have compared this against the relevant parts of HSE's nuclear SAPs.[5] To help us in this task, we developed a strategy to define both the technical areas to be sampled and those SAPs[5] most relevant for GDA Step 3 of the GDA process and we planned and conducted our assessment accordingly.

In doing this, we took account of our expectations for modern reactors, as described above. So our sample included the defence-in-depth provided by the systems for shutting down and cooling the reactor, and for the containment of radioactivity.

## Technical Support Contractors

As part of our drive to increase the pace of GDA, we have placed work packages with contractors to help us carry out our detailed technical assessment. We established a framework agreement, including 31 Technical Support Contractors, across a range of 15 technical areas using the Official Journal of the European Union (OJEU) process.

It is common practice for us to engage specialist contractors in this manner to give technical and scientific support and advice to our assessment process. The scale of GDA and the timescale we are operating to, means that we are undertaking significant amounts of assessment work and therefore need significant additional technical support. We have thus far placed over 40 separate contracts under this framework in support of GDA.

However, all regulatory decisions in the GDA process will continue to be made by the Nuclear Regulators – not by contractors.

# Main features of the design and safety systems

The UK EPR as proposed to us by EDF and AREVA is described in the UK EPR EDF and AREVA's Pre-construction Safety Report (PCSR).[6]

EDF and AREVA describe the UK EPR as an evolutionary four loop pressurised water reactor, with a net electrical output of between 1600 and 1660 MWe being an evolution of the French N4 and German Konvoi designs. The N4 series is the latest family of four PWRs commissioned in France at the end of the 1990s, and the Konvoi is a series of German PWRs commissioned in the early 1990s. EDF and AREVA claim that the UK EPR meets the 2000 version of the Franco–German technical guidelines developed between 1993 and 2000 and has a good level of compliance with the European Utility Requirements. The design therefore draws maximum benefit from the operating experience of the French and German fleets.

The UK EPR core can accommodate different fuel assembly designs. There are 241 fuel subassemblies, each containing 265 fuel rods. It is designed for enrichments up to 5wt% $U^{235}$, for high fuel burn-up (up to 60GWd/t).

The core is contained in a reactor pressure vessel (RPV), and the reactor coolant system is a conventional design. The primary heat transfer mechanism is pressurised light water in four loops circulating through the core, transporting the heat to the four steam generators. The steam from the steam generators is transported to the single turbine by the secondary circuit pipework.

EDF and AREVA claim that the general layout of primary and secondary circuits closely resembles the N4s, with a few significant differences.

- Larger primary and secondary water volumes to increase the thermal inertia of the system and slow down changes of temperature in transients.
- The provision of a larger RPV. There is a heavy neutron reflector (baffle) between the core and the RPV to reduce the neutron fluence on the vessel, which is claimed to reduce the effect of irradiation embrittlement of the RPV.
- There are no RPV bottom penetrations. Removal of the bottom mounted in-core penetrations has the advantage of removing the risk of having to repair leaking penetrations in very adverse conditions, as well as that of facilitating implementation of a core catcher in the reactor pit.

EDF and AREVA claim that the main safety systems, safety injection, steam generator emergency water feed and supporting electrical systems are designed along a four train architecture (which gives four separate lines of protection for design basis accident sequences). Each safety train is set up in a separate building. Furthermore, two of these four buildings are 'bunkerised' to strengthen their resistance to external hazards (as is the fuel building).

EDF and AREVA claim that the UK EPR safety systems are designed to mitigate the consequences of plant failures, ensuring reactor shutdown, removal of decay heat and prevention of radioactive releases. Key systems identified by EDF and AREVA are described below.

## Reactor shutdown

- Reactivity is controlled by adjusting the boron concentration in the primary circuit and by adjusting the position of the rod control cluster assemblies (RCCA). The RCCAs are a fast shutdown system consisting of 89 rod control assemblies containing neutron-absorbing materials. EDF and AREVA claim that the boration system is designed to satisfy long-term subcriticality requirements and ensure fast reactor shutdown, for example in case of rods failing to insert in the core.

## Emergency cooling

- The emergency feedwater system supplies water to the steam generators to maintain water level and remove decay heat following a loss of normal feedwater supplies.
- In the unlikely event of a loss of cooling accident, there is a Safety Injection/ Residual Heat Removal System consisting of four independent trains, each providing injection capability by an accumulator pressurised with Nitrogen gas, a Medium Head Safety Injection System and a Low Head Safety Injection System. The High Head Injection System, conventional in other pressurised water reactors, has been replaced by the Medium Head Safety Injection System. This has been made possible by the large volume of reactor water and EDF and AREVA claim this can have benefits in some accident scenarios. Each of the four safety injection trains is provided with a separate suction connection to the In-containment Refuelling Water Storage Tank (IRWST).
- The IRWST is the source of borated water for safety injection and containment cooling in the event of a severe accident. In addition, the IRWST collects water discharged from the Reactor Coolant System, allowing it to be recirculated by the Safety Injection System.

## Containment

- The UK EPR has a double concrete containment. The inner containment is made of pre-stressed concrete with a steel liner. The outer containment is made of reinforced concrete and is primarily intended to withstand severe external hazards (aircraft crash, explosion, etc). There is a containment heat removal system to control the containment pressure in the event of a severe accident.

## Core meltdown

- EDF and AREVA claim that the conception of the UK EPR decreases the potential core meltdown frequency by a factor of ten compared to plants presently in operation. In addition, in the unlikely event that core melt should happen, EDF and AREVA claim that the following UK EPR systems would limit the consequences:
  – a depressurisation system to prevent pressurised meltdown;
  – a ‘core catcher’ to cool and contain the molten Corium (ie the mix of fuel and reactor internals resulting from the meltdown of the core) if it were to escape the RPV;
  – implementation of catalytic recombiners inside the containment, to significantly reduce the likelihood of hydrogen reaching a potentially explosive concentration; and
  – a spray system dedicated to pressure control and cooling inside the containment after meltdown.

# Summary of HSE findings

This section summarises the findings of the system design and security review which comprised Step 3 of the GDA process.

## Internal hazards

Our safety assessment within this topic includes hazards such as fire, explosion, flood, dropped loads, pressure part failure, and steam release etc. within the reactor buildings. We have considered the adequacy of: the identification of hazards; prevention of hazards; and the protective barriers, segregation, separation, and active protection systems that are included within the design to provide mitigation in the unlikely event that such internal hazards should occur.

For GDA Step 3 our assessment sample covered internal hazards elements of the PCSR[6] and supporting documentation that focused on an examination of the principle claims and arguments presented by EDF and AREVA for redundancy and segregation of plant and equipment important to nuclear safety.

Redundancy is achieved through four 'trains' of protection, with each train able to provide 100% of the safety duty required to enable safe shutdown and post trip cooling. (A 'train' of protection includes all the elements necessary to perform the safety function, for example water source, pumps, pipes, electrical supplies etc). Additional protection comes from the physical segregation of each of the trains.

We also sought to confirm, or otherwise, that the observations made during GDA Step 2 had either been addressed or were in the process of being addressed during GDA Step 3.

From our GDA Step 3 assessment we have concluded the following.

- There are areas where full segregation has not been achieved; in these situations claims and arguments have been presented relating to the application of additional passive protection and the use of geographical distance to separate the trains.
- Although we are generally satisfied with the claims and arguments as laid down within the current PCSR[6] and other supporting submission case documents, we have requested that EDF and AREVA improves the arrangements for ensuring the integrity of hazard barriers through implementation of door control measures EDF and AREVA have agreed to achieve this through a design modification.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- Our review of the evidence provided by EDF and AREVA to support their claims and arguments.
- Our assessment of EDF and AREVA's plant layouts including cable runs.
- Our assessment of EDF and AREVA's improved arrangements for ensuring the integrity of hazard barriers through implementation of door control measures.

In summary, there is additional work to be done by EDF and AREVA to satisfy our questions in the internal hazards area and to make and present an adequate safety case. However, we consider that this is achievable within the GDA Step 4 timeframe, and in sufficient time to allow us to carry out a meaningful GDA assessment. At this stage, it is too early to say whether any of the additional work undertaken will identify the need for further design modifications.

## Civil engineering and external hazards

Our assessment of civil structures includes consideration of the integrity of structural components such as steel-framed buildings, concrete structures such as walls and the containment, and the reactor building foundations.

Our assessment of external hazards includes those natural or man-made hazards that originate externally to both the site and the process and over which the operator has little control. External hazards include earthquake, aircraft impact, extreme weather, and flooding, and the effects of climate change. Terrorist or other malicious acts are also assessed as external hazards.

For GDA Step 3 our civils and external hazards assessment approach was to confirm that the observations made in our GDA Step 2 assessment had been adequately addressed and to assess, by sampling, the arguments and, where applicable evidence that support the high level claims that were assessed in GDA Step 2.

A complication for this assessment topic area is the site dependent nature of both the magnitude of the external hazards or the local conditions which may dictate design choices. As a consequence there are a large number of areas where definitive statements over the acceptability of the design cannot be confirmed until Phase 2 (site licensing).

From our assessment we have concluded the following.

- The analysis and design of the UK EPR civil structures has been undertaken using primarily French or European codes and standards, about which our knowledge was limited at the start of GDA Step 3.
- Assessment of the rationale behind the development of the design basis load cases within the documentation has proved difficult. However, we consider that we are now broadly content with the process used and the final outcome.
- From work done so far on the assessment of the analysis codes used to predict the behaviour of the structures during extreme loading scenarios, the indications are that for those codes where we have been able to examine the documentation in detail, these will be found to be suitable for their chosen application. For a number of other codes, work is still ongoing.
- The use of the French design code for civil structures ETC-C was examined in some detail. There are a number of areas where we are questioning the approach adopted at a fundamental technical level. For example we believe the ETC-C or the French national Annexe may modify the Eurocodes in a manner which is potentially non-conservative by comparison with either other extant nuclear standards or with UK regulatory expectations.
- We are continuing assessment work to satisfy ourselves that suitable levels of reliability can be provided by the design codes used by EDF and AREVA.
- The inner containment was examined in some detail for two key reasons; because of the safety demands placed upon it, and because of the use of bonded prestressing tendons in the design. The latter is a novel approach in the UK for nuclear applications. We have been unable as yet to gain sufficient confidence in the likely quality of the construction, or the capability of the through-life monitoring and testing regimes, for bonded prestressing tendons.
- Initial progress on the assessment of the aircraft protection shell has been slow due to difficulties in exchanging security sensitive (protectively marked) information. However, we anticipate that we should be able to progress our assessment in this area during GDA Step 4.
- We are broadly satisfied that the claims and arguments as laid down within the current PCSR[6] are broadly in line with our expectations. However, there is a considerable amount of evidence to be provided to support these arguments.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- EDF and AREVA to make and present an adequate safety case that includes additional evidence to support the claims and arguments made.
- Our further consideration of the inner containment design to provide us with confidence on the use of bonded prestressing tendons.
- Our detailed review of the use of the design codes. There are a number of technical areas which will require resolution ahead of our acceptance of the approach adopted by EDF and AREVA.
- Our assessment of the proposed aircraft protection shell design.

In summary, there is a significant amount of additional work to be done by EDF and AREVA to satisfy our questions in the civil engineering and external hazards area and to make and present an adequate safety case. However, we consider that this is achievable within the GDA Step 4 timeframe, and in sufficient time to allow us to carry out a meaningful GDA assessment. It is possible that this additional work might identify the need for some modification to the design of civil structures. Also, because of the site dependent nature of this topic, some aspects may require resolution as part of site specific assessments.

## Probabilistic Safety Analysis

Probabilistic Safety Analysis (PSA) is an integrated, structured, logical safety analysis that combines engineering and operational features in a consistent overall framework. It is a quantitative analysis that provides measures of the overall risk to the public that might result from a range of faults (for example, failure of equipment to operate, human errors, or hazards such as fires). PSA enables complex interactions, for example between different systems across the reactor, to be identified and examined and it provides a logical basis for identifying any relative weak points in the proposed reactor system design.

For GDA Step 3 our assessment has examined the arguments presented by EDF and AREVA (ie the methods, techniques and scope of the PSA) that support its high level safety claims. In addition, we have reviewed in detail the part of the PSA that deals with the 'identification of internal initiating events during operation at power' to confirm whether the basis of the PSA is robust and to gain confidence on its completeness.

From our assessment we have concluded the following.

- EDF and AREVA submitted a full scope, modern PSA in support of the UK EPR which covered all modes of operation, and included consideration of internal and external hazards and the effect of preventative maintenance. There are necessarily some areas where the analysis is incomplete or at an early stage, since detailed design information is not yet available, but these are identified within the PSA.
- For some aspects of the PSA, the required depth of information was not contained in the submitted documents and/or the reference trail to that information was not clear.
- We asked EDF and AREVA to undertake sensitivity studies using the PSA model to demonstrate the impact of different levels of reliability and independence on the performance of the Control and Instrumentation (C&I) systems. This work gave results that challenged ND's numerical targets, as presented in our SAPs.[5] This underlines the importance of resolving the Regulatory Issue raised in the C&I topic area, concerning the system architecture and claimed reliabilities (see C&I section).
- In PSA, initiating events or faults are those disturbances (for example the failure of a system to operate, or the start of a fire in an electrical system) that demand/require operation of safeguard systems to prevent radioactive releases. The

initiating event identification process for the UK EPR design conforms with current PSA standards and is satisfactory, although further confirmatory work required in this area.

- The PSA produced by EDF and AREVA covers the areas we would expect to see in the scope of a nuclear power plant PSA. For the most part the methods and techniques used by EDF and AREVA are acceptable.
- The results of the PSA show that the risk to the public is low and estimated risks are generally better than the Basic Safety Objectives given in our SAPs.[5]

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided by EDF and AREVA. These include the following items.

- EDF and AREVA have committed to make changes to the UK EPR C&I architecture and we will need to review the impact of these changes on the PSA. In the event that revised PSA results exceed those quoted in the PCSR,[6] we may need to revisit the arguments that demonstrate that the risks are as low as is reasonably practicable (ALARP). Similarly any other potential engineering or operational shortfalls identified during our ongoing assessment may require further ALARP justification.
- We will review how unavailability due to maintenance is modelled in the PSA.
- We will review EDF and AREVA's modelling of large loss of coolant accidents (LOCA) initiating events.
- We will review EDF and AREVA's selection and justification of initiating event data and component failure rates.

Whilst the PSA appears reasonable at this point in our assessment, the need for design changes arising from our Step 4 assessment findings cannot be discounted at this time.

## Design basis analysis/fault studies

The design basis analysis and fault studies are the safety analyses of nuclear reactors on matters such as reactor core physics, thermal hydraulics, heat transfer and a wide range of other physical phenomena under steady state, transient and fault conditions.

Fault analysis involves a detailed study of the reactor system, its characteristics and mode of operation, with the aim of identifying possible faults that might occur and lead to the release of radioactive material. This is followed by a thorough examination of the conditions brought about by those faults. In particular, for those conditions which might affect the integrity of the nuclear fuel, the aim is to demonstrate the adequacy of the engineered protection systems in preventing a release of radioactive material.

This is a topic area where we did not have sufficient resource in place at the beginning of GDA Step 3 and this has limited the sampling that we have been able to undertake. We now have recruited additional staff to cover this topic area and intend to significantly accelerate our assessment during GDA Step 4. During GDA Step 3, our assessment has concentrated on reviewing the core design, design basis analysis and certain aspects of the severe accident analysis.

From our assessment we have concluded the following.

- EDF and AREVA have provided a safety analysis that is generally satisfactory but there are still some areas where further work and additional information is required. We see no fundamental reason to believe from the fault study perspective that a satisfactory safety case cannot be made for the UK EPR.

- In general, the range of faults considered within the PCSR[6] is less comprehensive than we require and we are asking EDF and AREVA for additional work in this area. Nevertheless, there was adequate information to enable a characterisation of the fault conditions on the UK EPR to be made for the purposes of our GDA Step 3 assessment.
- EDF and AREVA will be required to provide more comprehensive information within the PCSR[6] for us to assess during GDA Step 4. For example, judgements regarding the importance of the basic assumptions in fault analysis depend upon sensitivity studies in which input information is varied. While some information of this kind has been made available, more comprehensive sensitivity analysis will eventually be necessary.
- The design basis analyses presented are only concerned with single events as initiators of a fault sequence. Attention needs to be paid to complex situations in which a combination of events may initiate a fault sequence.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided by EDF and AREVA. These include the following items.

- EDF and AREVA needs to demonstrate that the list of design basis initiating events is complete and can be reconciled with the list of initiating events in the PSA.
- EDF and AREVA needs to review all design basis initiating events with a frequency of greater than 1x10-3 per year and demonstrate that a diverse safety system, qualified to an appropriate standard, is provided for each safety function. The single failure criterion also needs to be extended to include passive failures.
- EDF and AREVA needs to describe what limits and conditions they are proposing for the fuel safety technical specifications.
- EDF and AREVA needs to demonstrate that the fuel is protected from pellet-clad interaction (PCI) failure for frequent faults.
- The response to loss of coolant accidents is generally to shut down the reactor and initiate a partial cool-down through the controlled depressurisation of the steam generators. EDF and AREVA needs to provide more analysis of the planned cool-down rate to demonstrate the adequacy of medium head safety injection for the relevant range of loss of coolant accidents.
- The group of faults that include the low probability of failure to trip the reactor by insertion of control rods (the so-called Anticipated Transient without Trip (ATWT) faults) need to be included by EDF and AREVA within the design basis. Related to this, an ALARP justification for not installing an emergency boration system equivalent to the one at Sizewell B will also be required from EDF and AREVA.
- One of the faults considered in EDF and AREVA's analysis is the potential to suddenly increase the reactivity of the reactor due to dilution of the boron that is normally present in the primary coolant, for example by a 'slug' of water from the secondary systems. EDF and AREVA needs to improve the safety case in this area.

In addition to examining the outcome of the above, in GDA Step 4 we will:

- extend our assessment to examine the thermal hydraulic analysis performed in support of the PSA success criteria;
- review the internal and external hazards assessment safety cases from a fault study perspective; and
- review in detail the validation of the computer codes and carry out independent confirmatory analyses for selected cases.

The work to address some of our concerns may ultimately require changes to the plant design. In our judgement, these changes largely would be associated with changes to the reactor protection system (a major change has already been proposed but came too late to be taken into account in our GDA Step 3 assessment) or the qualification of safety systems to an appropriate standard.

## Reactor protection and control

Control systems are typically those that are used to operate the plant under normal conditions and reactor protection systems are those safety systems that are used to maintain control of the plant if it goes outside normal conditions. The assessment in this topic area includes reviews of both hardware and software aspects. This topic is also commonly referred to as both Control and Instrumentation (C&I) and confusingly I&C, but we will refer to the former throughout this report.

For GDA Step 3 our assessment sample covered topics of particular relevance to C&I system level design including review of C&I system architecture and diversity of systems implementing reactor protection functionality.

From our assessment we concluded the following.

- EDF's and AREVA's safety arguments set out in the PCSR[6] include a claim of compliance to French C&I standards and guidance, and C&I provisions that would be expected of a modern nuclear reactor such as:
  - safety systems (eg reactor shutdown systems such as the Protection System (PS));
  - plant control and monitoring systems (eg the Process Automation System (PAS) and Process Information and Control System (PICS)); and
  - main control room with backup via the Remote Shutdown Station (RSS) and communication systems for information transfer within and external to the plant.
- The PCSR[6] and supporting documentation address the main C&I systems expected in a modern nuclear reactor but the safety case arguments need improving.
- We identified significant concerns in relation to the adequacy of the UK EPR architecture, namely;
  - it is complex and has a high degree of interconnectivity, which results in a lack of independence between control and protection systems;
  - the reliability claims for the computer based Systems Important to Safety (SIS) go beyond what is accepted as normal practice and we believe would be difficult to substantiate; and
  - there is an absence of safety classified displays and manual controls in the control room.
- These issues were sufficiently important for us to raise a Regulatory Issue and we asked EDF and AREVA to respond to it with some priority. We have been encouraged by the positive response of EDF and AREVA to the concerns that we raised. They have proposed a way forward which includes provision of a non-computer based backup system, safety classified displays and manual controls in the control room, reduction of reliability claims for the computer based SIS and other measures such as one-way communication from high to lower classified safety systems. We anticipate that the proposed modifications will be acceptable, but we await the full details.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- Improvement of EDF and AREVA's safety case arguments.
- Our review of the evidence to support the claims and arguments identified in our Step 2 and 3 assessments.
- Our assessment of EDF and AREVA's proposed modification to the EPR C&I architecture in relation to the Regulatory Issue that we raised.

We expect EDF and AREVA to be able to provide additional information on the proposed modifications to the C&I architecture in time for us to assess during GDA.

However, in the event that significant information will only become available during the Phase 2 site specific (licensing and construction) work our assessment of it would have to be deferred until that time. If this is the case then this information will not be included within GDA.

## Essential electrical power systems

Many of the important systems on a nuclear power station require electrical power for their operation (pumps, valves etc). The safety assessment in this topic area typically therefore covers the engineering of the essential electrical power supply systems, examines these under a wide range of transient and fault conditions, and considers their likely reliability, and the performance of protection devices.

This is a topic area where we did not initially have sufficient resource and our assessment only commenced part way through GDA Step 3. This had the consequence of limiting the sampling that we have been able to do thus far but we intend to significantly accelerate our assessment during GDA Step 4.

During GDA Step 3 our assessment has concentrated on electrical systems reliability aspects, examining the scope and extent of arguments and considering whether the overall design is balanced in terms of the different contributors to the overall risk from the plant (ie considering what electrical plant failures could occur and whether there is adequate protection to protect against or cope with such failures). We also considered the need for additional regulatory analysis and modelling of the electrical system under normal and fault conditions.

We have concluded that EDF and AREVA provided a safety analysis that was generally satisfactory for GDA Step 3 and we have not, as yet, identified any fundamental issues in the electrical system design which would require significant changes to it.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- EDF and AREVA to provide further information for the following electrical system sub topics:
  – maintenance philosophy;
  – DC system design, operation and monitoring;
  – electrical system fault studies and load flows;
  – electrical protection and relay discrimination;
  – transient stability studies; and
  – earthing arrangements for 10Kv system.

- We will review the above information and in addition undertake some independent analysis in the following sub topic areas:
  – electrical system fault studies and load flows;
  – electrical protection and relay discrimination; and
  – transient stability studies.

Whilst the electrical system design appears reasonable at this point in our assessment, the need for design changes arising from our GDA Step 4 assessment findings cannot be discounted at this time.

## Fuel design

Within this topic we typically look at the performance of the reactor fuel under a wide range of reactor and storage conditions.

This is a topic area where we did not have sufficient resource in place at the beginning of GDA Step 3 and this has limited the sampling that we have been able to do. We now have sufficient staff to cover this topic area and intend to significantly accelerate our assessment during GDA Step 4.

Our GDA Step 3 assessment concentrated on:

- areas where experience has highlighted fuel performance shortfalls, including the effects of fuel assembly irradiation growth and the formation of crud and stress-corrosion cracking in power transients;
- a review of the design criteria against which the cladding integrity is assessed. This is important for the fuel design because these parameters determine the boundary of safe operation for the fuel and are a basis for judging the success of fault analysis; and
- consideration of the need to demonstrate compliance with the ALARP principle and to follow international good practice.

From our assessment we have concluded that EDF and AREVA have provided a wide ranging safety analysis in the fuel design topic area and that the substantiation of claims and arguments is generally adequate for GDA Step 3. However, the clarity with which the fuel design criteria are defined and justified should be improved.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided by EDF and AREVA. These include the following items.

- Our assessment of the EDF and AREVA case for prevention of fuel cladding cracks (due to thermal stress) in potential fault transients.
- Our assessment of the effect of in-core conditions on fuel critical heat flux.
- Our assessment of the effect of crud on the surface of the fuel pins.
- The demonstration of safety by EDF and AREVA of the long-term storage of the fuel before final disposal, including focussing on the role of the levels of burnup.
- EDF and AREVA need to improve the clarity with which they define and justify the fuel design criteria.

It is expected that the outstanding issues can be resolved by EDF and AREVA sufficiently before the end of GDA Step 4 and in sufficient time to allow us to complete a meaningful assessment.

## Reactor chemistry

The safety assessment of the chemistry of new nuclear reactors includes the effects of coolant chemistry on pressure boundary integrity, fuel and core component integrity, fuel storage in cooling ponds, radioactive waste (accumulation, treatment and storage), and radiological doses to workers.

This is a topic area where we did not have sufficient resource in place at the beginning of GDA Step 3 and this has limited the sampling that we have been able to do. We now have sufficient staff to cover this topic area and intend to significantly accelerate our assessment during GDA Step 4.

Our GDA Step 3 assessment concentrated on Identifying the key claims and arguments presented by EDF and AREVA in the PCSR[6] and supporting references.

From our assessment we have concluded that although EDF and AREVA have put considerable effort into the chemistry of the UK EPR the principle aspects of the demonstration of safety need improvement particularly in the following areas.

- The information provided to date by EDF and AREVA to describe the chemistry of boron in the primary circuit and the chemical effects in the secondary circuit and its ancillaries is limited and is not consistent with our expectations for GDA.
- The specific application of chemistry to accidents/severe accidents, is currently limited in detail.
- The chemistry case presented to date by EDF and AREVA is largely based upon experience from older plants supplemented by limited quantitative analysis. We wish to see a greater use made of quantitative analyses to support the case.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- Our assessment of the chemistry of accidents, including severe accident conditions. Our work in this area will be coordinated with equivalent fault studies assessment.
- EDF and AREVA will need to provide a topic report or PCSR[6] overview to address UK EPR chemistry.
- EDF and AREVA will need to provide further justification for zinc dosing.
- EDF and AREVA will need to provide further justification of the chemistry of boron in the primary circuit and chemical effects in the secondary circuit and its ancillaries.

The possibility of changes to the detailed design (eg for boronation, hydrogen control or the secondary circuits) as a result of these further chemistry assessments during GDA Step 4 cannot be ruled out.

## Radiological protection

This is a topic area where we did not have sufficient resource in place at the beginning of GDA Step 3 and this has limited the sampling that we have been able to do. We now have sufficient staff to cover this topic area and intend to significantly accelerate our assessment during GDA Step 4.

Our GDA Step 3 assessment strategy was to consider worker and public radiation exposure during normal operation, (including outages, maintenance and work such as refuelling). A key factor of the assessment was to consider whether the principles of radiological protection, namely optimisation and limitation, had been applied appropriately. In particular we considered whether exposure to radiation was restricted as low as reasonably practicable (ALARP).

From our assessment we have concluded the following.

- EDF and AREVA have provided a reasonable safety analysis of radiological protection for the principal plant for normal reactor operations.
- The substantiation of claims and arguments for radiation doses (worker and public) being ALARP is adequate for GDA Step 3.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- EDF and AREVA needs to provide the detailed evidence to demonstrate robustness of the ALARP arguments.
- We will assess the robustness of potential dose uptake based on evidence provided by the EDF and AREVA focusing on, in particular, worker exposure associated with the fuel route, shielding, ventilation, contamination control and plant radiation monitoring system.

- We will assess worker and public radiation exposure during accident conditions.

During our GDA Step 4 assessment of radiation protection there will be close liaison with other assessment areas, particularly human factors, probabilistic safety assessment, fault studies, mechanical engineering, reactor chemistry, radioactive waste management and decommissioning.

## Mechanical engineering

This typically includes the safety assessment of essential mechanical items important to safety such as pumps, valves, lifting equipment including cranes, fuel handling equipment, ventilation systems etc. It also includes the layout and routing of the mechanical equipment and systems to ensure appropriate maintenance regimes and protection from degradation.

Our GDA Step 3 assessment examined the claims and arguments and identified the evidence in EDF and AREVA's PCSR[6] and supporting documentation. As mechanical engineering covers a broad range of equipment types our assessment approach has been to review selected structures, systems and components (SSC) in terms of their safety functions against our regulatory expectations. Our assessment focused on the following.

- Assessing the scope and extent of claims and arguments presented
- Reviewing the level of design completeness.
- Assessing relevant aspects of the safety case, specifically safety categorisation and classification, design and reliability claims and equipment qualification.
- Considering whether the mechanical design aspects are likely to meet their safety functions in normal and fault conditions.
- Considering the layout, access, ingress and egress provisions to facilitate operation, inspection, testing, maintenance and equipment replacement.

From our assessment we have concluded the following.

- We now have a better understanding of:
  – equipment qualification processes applied by EDF and AREVA, specifically from the description of the reactor coolant pump Stand Still Seal System as an example; and
  – design process applied by EDF and AREVA, based on the assessment undertaken to date.
- The safety function categorisation and equipment classification methodologies applied by EDF and AREVA in their submissions are not entirely in accordance with international good practice.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- EDF and AREVA to develop and provide further information and clarification to demonstrate the alignment of UK EPR Safety Function Categorisation and Equipment Classification methodologies with international good practice. This topic impacts on some other technical topic areas and is discussed in more detail elsewhere in this report.
- We will review how the EDF and AREVA definition of safety functional requirements for mechanical items important to safety is promulgated from assembly down to component design, and then captured and retained through the design and implementation lifecycle.

Findings in GDA Step 4 may ultimately require changes to the plant design. It is however too early to form a judgement on the need or extent of any design changes.

## Structural integrity

This topic includes the safety assessment of nuclear safety related metal pressure vessels, piping, other components and their supports, including materials selection, design, fabrication, in-manufacture examination and testing, the analysis of structural integrity under normal load and faulted conditions (including fracture mechanics based analyses), and lifetime ageing of materials assessment (including neutron irradiation embrittlement).

For GDA Step 3, our assessment examined the arguments and identified the evidence relating primarily to the highest integrity structural integrity components such as the Reactor Pressure Vessel, Steam Generators and Pressuriser.

From our assessment we concluded the following.

- The French design code for pressure components (the RCC-M code, 2007 edition) is in general a sound basis for design and fabrication of the primary and secondary circuit pressure boundary components.
- For components where 'the likelihood of gross failure is claimed to be so low it can be discounted', EDF and AREVA have indicated a willingness to implement a more comprehensive method of achieving and demonstrating integrity consistent with this level of safety claim.
- The basis of Reactor Pressure Vessel construction with a circumferential weld at core mid height has been appropriately justified.
- The use of castings for the Reactor Coolant Pump Bowl construction has been justified. However, there are still aspects to resolve in how to deal with large repairs to the castings made by welding (this is a potential feature of the manufacturing process). The areas still open relate to how to obtain confidence that crack-like defects of a size of concern for integrity can be detected (defects might be introduced during the weld repair process).
- Useful progress has been made in understanding the approach to be used for setting Pressure-Temperature limit curves for the Reactor Pressure Vessel. However, there are aspects still to be resolved including the need for improved clarity and better referencing of what is proposed, and also consideration of what is ALARP.
- EDF and AREVA have proposed the use of Alloy 690 in the 'Thermally Treated' condition, and we consider this is a sound choice of material for Steam Generator Tubing.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided. These include the following items.

- We will review the evidence that justifies which components EDF and AREVA claim are of the highest integrity and for which they claim that 'the likelihood of gross failure is so low it can be discounted'.
- EDF and AREVA have proposed a programme to implement an appropriate approach to achieving and demonstrating integrity for components where they claim 'the likelihood of gross failure is so low it can be discounted'. We expect to see significant progress on this during GDA Step 4.
- We will assess and resolve with EDF and AREVA aspects of the chemical composition of the low alloy ferritic steels for the main vessels (Reactor Pressure Vessel, Steam Generators and Pressuriser).
- We will examine how EDF and AREVA propose to deal with any large repairs made by welding to the Reactor Coolant Pump casings that might arise in manufacture. We will be seeking assurance that crack-like defects of a size of concern for integrity can be detected in large repairs made by welding.

- We will continue to examine detailed aspects of the design code, for example regarding some of the RCC-M design analysis equations for pipework.
- EDF and AREVA will need to provide further clarity and better referencing of what is proposed, and also consideration of what is ALARP, concerning Pressure-Temperature limit curves for the Reactor Pressure Vessel.

A number of the areas identified for assessment in GDA Step 4 will require significant effort and programmes of work on the part of EDF and AREVA. Nevertheless, we believe it is practical to complete a meaningful GDA in this topic area during Step 4.

## Human factors

The safety assessment of the human factors (HF) aspects of the new nuclear power stations is focused on ensuring that the human actions that are needed to contribute to safety are feasible.

This is a topic area where we did not initially have sufficient resource and our assessment only commenced part way through GDA Step 3. This had the consequence of limiting the sampling that we have been able to do thus far but we intend to significantly accelerate our assessment during GDA Step 4.

For our assessment focused on the following.

- Confirming that the EDF and AREVA safety submissions provided a clear justification for the role of human actions, and that they understand and can justify the contribution of human actions to safety.
- Seeking assurance that EDF and AREVA have HF analysis to support the human based safety claims (for HSE assessment during GDA Step 4) and that the age of this supporting analysis is acceptable when compared to modern standards.
- Confirming that the standards used are appropriate and that there has been an adequate integration of HF into the UK EPR design, and into the PCSR[6] and supporting documents.

From our GDA Step 3 assessment we have concluded the following.

- The HF programme, activities and interactions included in the PCSR[6] do not present safety analysis and arguments in a clear and acceptable structure, or clearly highlight the human based safety claims.
- There does not appear to be an explicit link between the Probabilistic Safety Analysis (PSA) and HF work.
- EDF and AREVA have presented a consolidated overview of what they consider the human contribution to safety to be. Our consideration of the Human Reliability Assessment (HRA) for the Level 1 PSA concludes that there is sufficient consideration and modelling of pre-fault human failure events, to give us confidence in EDF and AREVA's understanding of the human contribution to safety.

For GDA Step 4, we have identified areas where further work is required, or where additional information needs to be provided by EDF and AREVA. These include the following items.

- We will focus on those areas where the human contribution to safety is greatest and we will assess the arguments and evidence underpinning the human based safety claims.
- EDF and AREVA will need to provide further clarification on standards and procedures applied to HF aspects.

Some of this work will require additional effort on the part of EDF and AREVA, nevertheless, we believe it is practical to complete a meaningful GDA in this topic area during Step 4.

## Quality management and safety case development arrangements

This topic addresses the EDF and AREVA Quality Assurance and Management of Safety arrangements, that is to say the organisational and procedural arrangements, to deliver the UK EPR PCSR[6] and supporting documents.

We included in GDA Step 3:

- our assessment of the Project Quality Assurance Plan and the QA related sections of the PCSR;[6]
- our inspection (jointly with the Environment Agency) in April 2009 of:
  - the implementation of selected project related EDF, AREVA and joint project arrangements. Of particular interest were the control of submission documents and design change control; and
  - the assessment of both EDF's and AREVA's review and audit and the learning from experience procedures applied to the UK EPR project.

From our assessment we have concluded the following.

- The EDF and AREVA organisational and quality assurance arrangements for the UK EPR GDA Project Team have been operating throughout GDA Step 2 and 3 and are well established.
- The joint project arrangements are supported and supplemented within EDF and AREVA by well developed QA arrangements. The Project Quality Assurance Plan is supported by a number of joint procedures which have been implemented.
- Our inspection raised a number of aspects for consideration by EDF and AREVA including:
  - clarification of the role of Independent Nuclear Safety Assessment and Independent Peer Review as applied to design changes and to environmental aspects of the design;
  - extension of auditing programmes to cover all GDA support contractors; and
  - the need for review of current arrangements for managing and tracking non-conformances arising from their auditing activities with implementation of improvements where appropriate.
- The UK EPR design reference point was 'frozen' in December 2008. Any design changes arising from the developing Flamanville 3 design, or those proposed by EDF and AREVA in response to issues raised in our GDA assessment, will be subject to appropriate change control procedures commensurate with the safety significance of the proposed change
- Some changes from the Flamanville 3 design have been proposed by EDF and AREVA for incorporation in the UK GDA EPR design. However, we have not yet received the details.
- The development of design detail and cut-off dates for inclusion of additional information within GDA require further dialogue with EDF and AREVA.

For GDA Step 4, we have identified areas where we will undertake further assessment or inspection. These include the following items.

- The effectiveness of EDF and AREVA's improvement measures put in place to address our inspection findings.
- Control of design changes proposed by EDF and AREVA for inclusion in the UK EPR.

- EDF and AREVA arrangements for the control of design detail development (System design manuals).
- EDF and AREVA procurement arrangements including processes for selection of manufacturers.
- EDF and AREVA arrangements for delivery of design intent.
- EDF and AREVA arrangements for transfer of UK EPR design knowledge to prospective licensees.

## Radioactive waste and decommissioning

Under this topic, we typically examine the proposals for the safe minimisation, handling, storage and disposal of radioactive waste arising from all parts of the power station, and we review the proposals for decommissioning.

In undertaking our GDA Step 3 assessment, we have worked closely with the Environment Agency and Department for Transport (DfT) to ensure that all significant waste arisings and discharge routes have been identified by EDF and AREVA and that those wastes can be effectively managed.

At the start of Step 2 of the GDA process the level of information on the management of radioactive waste was limited. Additional information has since been provided and we have been able to progress our assessment.

For GDA Step 3, our assessment looked at the safety case presented in the PCSR and supporting safety documentation and the claims, arguments and evidence provided. Our assessment included consideration of the type of waste produced, including spent nuclear fuel, and the long-term storage of this waste.

In view of the wide level of public interest in Radioactive Waste and Decommissioning, our GDA Step 3 assessment has also taken account of feedback from a wide range of stakeholders.

From our assessment we have concluded the following.

- EDF and AREVA's PCSR[6] and supporting references include the source and types of radioactive waste produced; the design and operation of the at-reactor spent fuel pond; details of the Waste Treatment Building, (which will house the processing and packaging systems for operational wastes other than spent fuel); proposals for an Intermediate Level Waste (ILW) storage facility that will provide retrieval, inspection and, if necessary, refurbishment of waste packages; and a number of options for the long-term storage of spent fuel.
- EDF and AREVA have stated that the radioactive wastes produced by a UK EPR are suitable for disposal. They also requested a written disposability assessment from the Nuclear Decommissioning Authority (NDA). This is now complete but was not available in time for consideration in GDA Step 3.

For GDA Step 4, we have identified areas where we will undertake further assessment. These include the following.

- EDF and AREVA's spent fuel and radioactive wastes management arrangements.
- EDF and AREVA's proposals for how an operator should safely prepare and store the waste so that it is appropriate for disposal (ie how compatibility with the conclusions of the NDA disposability assessment will be assured).
- EDF and AREVA's proposals for decommissioning.
- The NDA's disposability assessment and EDF and AREVA's comments on it.

## Security

Under this topic we consider whether the security protection provided on the nuclear power station is adequate to protect against the theft or sabotage of nuclear materials or associated facilities.

During GDA Step 3, The Office for Civil Nuclear Security (OCNS) has gained good understanding of the security philosophy applied to the UK EPR design. No significant issues have been identified so far that would preclude this design from being adequately secured against malicious capabilities (as identified in the UK protectively marked Nuclear Industries Malicious Capabilities Planning Assumptions document).

## Safeguards

Nuclear safeguards are measures to verify that States comply with their international obligations not to use nuclear materials (eg plutonium ans uranium) for nuclear explosives purposes. Global recognition of the need for such verification is reflected in the requirements of an International Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The safeguard measures that currently apply in the UK include the provision of the nuclear material accountancy information and independent inspections by the International Atomic Energy Agency (IAEA) and the European Commission to verify the facility design, the fuel inventory and associated records.

Any new nuclear reactors built in the UK will also be subject to safeguards obligations. HSE is encouraging early engagement with EDF and AREVA to ensure that the design of the UK EPR allows for the appropriate safeguards measures. During GDA Step 3 we have made initial contact with EDF and AREVA on this topic and we will continue further interaction during GDA Step 4.

## Issues raised through the public involvement process

We recognise the importance of building public confidence in our ability to protect people and society from the hazards of new nuclear power stations, and that working in a way that is open and transparent is a good way of helping build that confidence.

The GDA process was designed to be open and transparent, and decisions were taken early on to encourage the Requesting Parties to publish their safety, security and environmental submissions and to invite comments from the public on those. Summaries of the comments received are published in reports on the ‘public involvement process’ at the end of each step of the GDA process.

During GDA Step 3 a total of 45 comments were received of which; 26 were directed at the Requesting Parties and 19 at HSE. Of these, 32 related to the designs being assessed, three related to the GDA process more generally, and ten fell outside the scope of GDA.

Issues raised on the UK EPR included: the types of spent fuel cask proposed (for dry fuel storage); the inclusion and quantification of external hazards, and the justification for stated bonding limits for example for earthquakes; the stated fuel melting temperatures; and the segregation of intermediate level waste and plans for its encapsulation, storage and disposal. EDF and AREVA have responded to all relevant comments and we and the Environment Agency took these into account, where appropriate, in our respective GDA Step 3 assessment.

In addition to this, we have revised the GDA website to make it easier to use. This currently receives around 5000 visitors per month. We use the website extensively to publish information on the GDA process. We also continue to publish joint 'new-build' e-bulletins with the Environment Agency to notify subscribers of any new developments.

As well as publishing general information, our GDA guidance and technical assessment reports, we have started publishing a range of other useful documents, including joint Quarterly Reports. These summarise where we are, highlight the key future challenges we face going forward and any regulatory issues we have raised against each of the designs we are assessing.

We also continue to speak at regional, national and international events, and proactively organise seminars for key stakeholders. During GDA Step 3, this included organising two events for non-governmental organisations and two for potential operators.

For more information on the public involvement process for GDA Step 3 see *Update on the Public Involvement Process for GDA Step 3 of the Generic Design Assessment Process*.[8]

## Working with overseas regulators

Our strategy for working with overseas regulators during GDA is given on our website.[9] In accordance with this, we have, throughout GDA, worked with overseas regulators, particularly those in France (ASN), Finland (STUK) and the USA (US NRC), where the EPR is also being assessed by these regulatory authorities. We have used these exchanges both to help our assessment (and theirs) during GDA Step 3 and to confirm that we are applying the best international standards.

This work has taken several forms in different topic areas.

- Taking information simply from overseas regulator websites.
- Sharing technical reports.
- Conducting joint inspections.
- Having bilateral or multilateral face-to-face meetings.

Of particular benefit have been the bilateral and trilateral information exchange meetings with our overseas counterparts. Topics discussed have included control and instrumentation, probabilistic safety analysis, human factors, civil engineering, reactor fuel, fault analysis, reactor chemistry and oversight arrangements for long lead items.

A particularly significant exchange was the trilateral discussions with ASN and STUK about our shared concerns on the C&I architecture. This allowed us to develop a common approach, which was summarised in a joint ASN-STUK-HSE press release www.hse.gov.uk/press/2009/hse221009.htm. This was a good example of how independent regulators working closely together can promote a shared understanding and application of existing international standards, and promote the harmonisation of regulatory standards and the build of reactor designs with the highest levels of safety.

In addition we have participated in working group meetings of the Multi-national Design Evaluation Programme (MDEP) (see www.nea.fr). The aim of MDEP is to promote international sharing of information between regulators on their new nuclear power station safety assessments and to promote consistent nuclear safety assessment standards among different countries. The participants are ten countries where new nuclear power station programmes are commencing, USA, Canada, China, France, Japan, the Russian Federation, UK, Republic of Korea, South Africa and Finland, plus the IAEA. HSE represents the UK and takes a full part in the information sharing activities. In specific meetings related to EPR, discussion has included the following topics: C&I; PSA; Human Factors; and oversight of manufacturing and fabrication of long lead items.

We have found these exchanges of information most valuable and we have taken account of them in the individual topic areas as appropriate.

For over ten years, ASN and HSE have exchanged nuclear inspectors on long-term secondments. From January 2007, an HSE inspector was seconded to ASN and worked on the French EPR project, and from September 2009 a member of the ASN has been working in HSE's GDA team. These exchanges help promote information flow between the two organisations and improvements in understanding of ways of working.

Interactions with our overseas regulatory colleagues will continue throughout GDA Step 4.

# Cross-cutting issues

A number of issues were identified during the GDA Step 3 assessment which affected several technical areas. These are discussed below.

## The demonstration of as low as reasonably practicable

Demonstration that the risks from the UK EPR are 'as low as reasonably practicable' (ALARP) is not an individual topic area but is a topic that runs across all the areas and has been considered implicitly within our topic safety assessments.

In respect of ALARP for GDA Step 3, we required EDF and AREVA to provide an explanation of how the decisions regarding the achievement of safety functions ensure that the overall risk to workers and public is ALARP.

In looking to see if this was achieved, we expected a clear conclusion that there are no further reasonably practicable improvements that can be made to the plant and that the standards, codes etc used have been justified to the extent that we can deem them to be 'relevant good practice' when viewed against our Safety Assessment Principles (SAPs)[5] and Technical Assessment Guides (TAGs). Furthermore, we were looking to see that there is safety rationale for the design options chosen, and a demonstration that it is not reasonably practicable to do more to reduce the overall risk. We are also keen to see that risk assessment has been used in the design process to help identify potential improvements.

From our GDA Step 3 assessment we have concluded that:

- EDF and AREVA consider the design to have reduced risks ALARP and they support this conclusion with reference to the design evolution of the UK EPR from its forerunners (the French N4 and German Konvoi nuclear power plants) and argue that the optioneering process developed over a period of 20 years has maximised safety.
- EDF and AREVA summarise 'relevant good practice' (RGP),in the PCSR[6] and include an overview of the codes and standards used together with comparisons with other codes etc. The PCSR[6] also describes the incorporation of Operational Feedback Experience and refers out to comparison with the SAPs[5] and the evolutionary approach to the design, allowing account to be taken of much worldwide experience.
- With respect to design options the PCSR[6] deals with optioneering during the design phase and a series of potential design enhancements aimed at risk reduction are cited and the rationale for each of the choices made is given.

- In addition to options already included in the design, the PCSR[6] considers further potential options for safety enhancement. These options include modification to the C&I system to introduce a hard wired back up. This is of particular interest in view of the concerns we have raised on the C&I (see elsewhere in this report). In the original ALARP assessment, EDF and AREVA concluded that the hard wired back up system was not reasonably practicable, but this pre-dated the issues we raised about the complexity of the C&I architecture and justification of reliability claims. In the light of our concerns, they have now agreed to introduce a hard wired back up system.
- With respect to Risk Assessment there has been good use made of PSA during the design phase and as part of the overall ALARP demonstration (see PSA section). In addition it is clear that the PSA elements are used together with deterministic engineering arguments to form the overall conclusions, which we consider to be good practice.

Our overall conclusion is that EDF and AREVA have made a reasonable effort in summarising the ALARP case and that they have clearly taken note of our guidance in doing so.

In GDA Step 4 we intend to sample the evidence underpinning the ALARP arguments that we reviewed in our GDA Step 3 assessments to assure ourselves that the methods and assumptions used are reasonable. In general this will be done within each of our assessment topic areas but we will also examine the ALARP arguments made at the overall level.

## Submission configuration control and design reference point

The safety submission freeze and the design reference point for GDA (sometimes referred to as the ‘design freeze’ for GDA) has been the subject of discussions with EDF and AREVA. This is important because we need to have an assurance that the designs and safety cases are sufficiently advanced and are not subject to significant change throughout the GDA process. An agreed design reference point is key to ensuring that there will be a sound basis against which to issue a GDA ‘Design Acceptance Confirmation’ (HSE) or a ‘Statement of Acceptability’ (Environment Agency), should this be appropriate at the end of our assessments.

The fact that the design is not currently complete has made agreement on a design reference point date more difficult. The UK EPR developing design presented by EDF and AREVA for GDA is based on the Flamanville 3 EPR design which is currently under construction in France. EDF and AREVA are seeking a harmonised EPR design to minimise design differences between future EPR plants. In some areas EDF and AREVA are offering to supplement UK specific information with detailed design information from Flamanville 3 and we are looking at some of this in our assessment, while noting that this does not form part of the formal GDA safety submission.

We agreed a frozen design reference point at December 2008 based on the Flamanville design at that time. However, despite us wanting a frozen reference point, we have to recognise that the design is developing and there will be design changes as a result of issues raised during our assessment and possibly as a result of design changes at Flamanville 3. We have therefore agreed in principle with EDF and AREVA that further design changes post the December 2008 freeze date could be considered by us as part of an agreed change control arrangement.

During GDA Step 3 we reviewed EDF and AREVA’s proposed arrangements for the control of design changes as part of our assessment of quality management and safety case development. We concluded that the arrangements for control of design changes appeared reasonable, however during GDA Step 4 we will seek evidence that these arrangements are being appropriately applied, particularly with respect to categorisation of design changes.

We will include statements of progress of our assessment of significant design changes as appropriate during GDA in our Quarterly Reports and we will confirm the status of these modifications at the end of GDA in our Step 4 reports. It is possible that we may refuse to accept some design changes into GDA if we believe the impact on our assessment programmes would be unacceptable.

This GDA design reference will then be used as the basis for any operator/ site specific design and safety submissions that may be made during any future licensing and construction in the UK.

### Categorisation of structures, systems and components

A nuclear power station is complex and contains many different structures and components. Some of these are more significant for safety than others, and its important to understand which are the most significant as this can effect the requirements for reliability of the system, and the quality requirements for construction and maintenance etc. This is done through a process called categorisation and classification.

The safety categorisation and classification of ‘structures, systems and components’ (SSC) is therefore an important element of a safety case. It allows a graded approach to safety, based on importance, and allows us to focus our assessment on those functions which are the most important to safety. It also helps ensure that appropriate codes and standards are applied, according to the safety requirements for that system, structure or component.

Our assessment of the UK EPR has, in some of our technical topic areas, shown that the EDF and AREVA system of Categorisation and Classification is not entirely in alignment with international good practice. An example, is on mechanical systems where there appears to be no classification system for delivery of a safety function. This contrasts with the electrical systems where there is an appropriate classification.

We are in discussion with EDF and AREVA on this topic and we will ask them to provide clarification on their methodologies for categorisation and classification and evidence to demonstrate how these align with international good practice. We will progress this within our GDA Step 4 assessment.

## Summary of significant issues

There is significant additional work to be done by EDF and AREVA to satisfy our questions, and to make and present an adequate safety case, in many of the technical topic areas. Throughout this report we have highlighted areas where we believe there is additional work to be done by EDF and AREVA and additional assessment to be done by us.

Key to progress towards completing a meaningful GDA assessment will be the quality and timeliness of the additional information provided by EDF and AREVA. If the additional information is delayed, or is insufficient to facilitate our GDA Step 4 assessment, then we will advise EDF and AREVA accordingly as we progress through GDA Step 4.

Areas where the issues we have raised are particularly significant include the following.

- Civil engineering: Progress remains slow in providing adequate responses to our questions on design codes and standards. We have not yet seen sufficient evidence to provide the confidence that these conform to the design standards we would expect to be applied to new nuclear construction.
- Civil engineering: We are looking for additional evidence to support the proposed use of bonded prestressing tendons in the containment structure.
- External hazards: Because of security considerations, it has taken some time for suitable arrangements to be put in place to allow the exchange of sensitive information, including the input data required to check that the design has adequate resistance to aircraft impact. These arrangements are now in place and this topic will be progressed in GDA Step 4.
- C&I architecture: Our assessment identified significant concerns about the complexity of the architecture and on the very high reliabilities that EDF and AREVA were claiming. In response EDF and AREVA have committed to deliver changes to the C&I design. These seem to be appropriate but we have yet to see the details.
- Internal hazards: We have requested improved arrangements for ensuring the integrity of hazard barriers through implementation of door control measures. EDF and AREVA have agreed to address this through a design modification. This seems to be an appropriate response, however, we have yet to see any of the design change details and so it is not yet possible for us to conclude on the acceptability of them.
- Structural integrity: We have raised a number of issues with EDF and AREVA; in particular relating to components where it is claimed that the likelihood of gross failure is so low that it can be discounted. We have asked EDF and AREVA to clearly identify for which components they are making this claim and we have also asked for an appropriate approach to achievement and demonstration of integrity for these components.
- Design changes: Modifications to the UK EPR reference design post the December 2008 freeze date may arise from either:
  – changes to the French Flamanville 3 EPR design which EDF and AREVA would like to include in the UK GDA; or
  – design modifications that are proposed by EDF and AREVA to address regulatory shortfalls (eg C&I architecture).

If we are unable to complete our assessments of proposed design changes within the GDA timeframe then those areas affected by the design change will either be identified as outside the scope of GDA or they may be identified as exclusions to any GDA Design Acceptance Confirmation ‘Certificates’ we may issue.

# Potential Exclusions

In conducting this GDA assessment, we have identified issues as early as possible in our assessment, and we will continue to do so. We discuss and progress these with EDF and AREVA, and attempt to resolve them. Those that we know of now are detailed in our supporting technical reports and are summarised in this report. If the responses to these are satisfactory, and we are content in all other respects that the reactor design meets HSE’s Nuclear Safety Assessment Principles (SAPs) and all other relevant considerations which we have set out, then we would conclude GDA positively for the UK EPR.

However, previous HSE and international experience has shown that in projects such as GDA it is not unusual for industry to take significant time to completely resolve some of the technical issues raised by regulators, in view of the need for new analysis, tests or research etc to be carried out. Thus, in these instances, a 'satisfactory' response to a technical issue could be one where the issue is not fully closed-out in GDA, but there is a planned way forward that we judge is acceptable. It might then be appropriate for us to allow the project to proceed in a controlled manner to the site specific phase, and it is in these circumstances that we would identify the remaining issues as 'Exclusions'.

It is important to note that 'Exclusions' in the GDA context does not refer to things that are excluded from our assessment, but rather it refers to items where we have carried out assessment and where further work is required in future to respond to our issues that have arisen out of that assessment. The items would therefore be excluded from the scope of our GDA 'Design Acceptance Confirmation'.

So, if we have 'Exclusions', it will be because we are not yet fully satisfied on these issues, but we are content enough in the overall design to issue a 'Design Acceptance Confirmation'. Where we have 'Exclusions' we will make it clear what our expectations are in relation to their resolution.

Using 'Exclusions' in this way is not a new concept; it is an existing mechanism that is used in conjunction with hold points that are regulated under Conditions attached to a Nuclear Site Licence. Hold points are programme milestones that allow us to regulate progress through construction in a controlled manner, with technical issues being linked to appropriate stages in the programme. We ensure that construction cannot proceed beyond a hold point until related technical issues have been resolved to our satisfaction. If they are not resolved, then further progress would not be permitted.

# Conclusions

This is an interim report on HSE's GDA work for the UK EPR reactor and it summarises our findings to date.

In undertaking this work we have:

- improved our knowledge of the design;
- identified significant issues;
- identified areas where significant design or safety case changes may be needed (for example C&I architecture); and
- identified major issues that may affect design acceptance and engaged with EDF and AREVA in attempting to progress them.

In doing the above and making our findings public we believe we have achieved a significant reduction in regulatory uncertainty.

Our work on GDA Step 3 has allowed HSE inspectors to further familiarise themselves with the design and safety case and has provided a basis for planning our GDA Step 4 assessment work.

We have undertaken an examination of the UK EPR at the system level and analysed EDF and AREVA's supporting arguments. From a security perspective, the foundations for developing the conceptual security plan have been laid through dialogue with EDF and AREVA.

In undertaking our GDA Step 3 assessment, we have worked with the Environment Agency to ensure that all significant waste arisings and discharge routes have been identified by EDF and AREVA, and that those wastes can be effectively managed. We have not identified any significant issues, or significant design or safety case changes that could impact on radioactive waste arisings or have a significant negative environmental impact.

In arriving at our conclusions thus far we have taken into account comments raised via our public involvement process and information exchanges with overseas regulators.

We continue to believe that the UK EPR could be suitable for construction on licensed sites in the UK. However, we have identified a significant number of issues with the safety features of the design that would first have to be progressed. If these are not progressed satisfactorily then we would not issue a 'Design Acceptance Confirmation' at the end of GDA Step 4.

In one topic area, C&I, we have raised significant concerns about the proposed architecture and EDF and AREVA has now agreed to address these by making design changes. Their initial proposals look reasonable but we have yet to see the design change details and so it is not yet possible for us to conclude on the acceptability of them.

As part of our assessment of internal hazards, we have requested improved arrangements for ensuring the integrity of hazard barriers through implementation of door control measures. EDF and AREVA have agreed to make such a change and are planning to implement this through a design modification.

For the other issues we have raised it is too early to say whether they can be resolved solely with additional safety case changes or whether they may result in design modifications being necessary.

If during our GDA Step 4 detailed assessment we identify an issue that impacts on radioactive waste arisings or other environmental impact, we will notify the Environment Agency, which is, in any case, a partner within the GDA process. We will do this through our routine joint working arrangements on GDA, and where appropriate in response to the Environment Agency's consultation process.

We will summarise progress on our GDA Step 4 assessment, and on the issues we have raised, in our joint Quarterly Reports with the Environment Agency, which we will continue to place on our website and in a final GDA report at the end of GDA Step 4, which is presently scheduled for June 2011.

# Abbreviations

| | |
|---|---|
| ALARP | As low as reasonably practicable |
| AREVA | AREVA NP SAS |
| ASN | Autorité de Sûreté Nucléaire (French nuclear safety authority) |
| ATWT | Anticipated Transient without Trip |
| C&I | Control and instrumentation |
| DECC | Department of Energy and Climate Change |
| DfT | Department for Transport |
| DTI | Department for Trade and Industry (now DECC) |
| EA | Environment Agency |
| EDF | EDF SA |
| EPR | European Pressurised-water Reactor |
| GDA | Generic design assessment |
| HRA | Human Reliability Assessment |
| HSE | Health and Safety Executive |
| IAEA | International Atomic Energy Agency |
| IEC | International Electrotechnical Commission |
| ILW | Intermediate level waste |
| IRR99 | Ionising Radiations Regulations 1999 |
| IRSN | Institut de Radioprotection et de Sûreté Nucléaire |
| IRWST | In-containment Refuelling Water Storage Tank |
| LLW | Low level waste |
| LOCA | Loss of coolant accident |
| MDEP | Multi-national Design Evaluation Programme |
| ND | Nuclear Directorate |
| NDA | Nuclear Decommissioning Authority |
| OCNS | Office for Civil Nuclear Security |
| OJEU | Official Journal of the European Union |
| PAS | Process Automation System |
| PS | Protection System |
| PCER | Preconstruction Environment Report |
| PCI | Pellet Clad Interaction |
| PCSR | Preconstruction Safety Report |
| PICS | Process Information and Control System |
| PSA | Probabilistic safety analysis |
| PSR | Preliminary safety report |
| QA | Quality Assurance |
| RCCA | Rod control cluster assemblies |
| RGP | relevant good practice |
| RI | Regulatory Issue |
| RP | Requesting Party |
| RPV | Reactor pressure vessel |
| RSS | Remote Shutdown Station |
| SAPs | Safety assessment principles |
| SFAIRP | So far as is reasonably practicable |
| SIS | Systems Important to Safety |
| SSC | Structures, Systems and Components |
| SSER | Safety, security and environmental report |
| STUK | The Finish nuclear safety authority |
| US NRC | Nuclear Regulatory Commission (United States of America) |

# Annex 1 Summary of HSE/ND's expectations for Step 3 of the GDA process

Details of HSE's expectations for Step 3 of the GDA process can be found in the GDA guidance.[1] From that document, the key expectations of Requesting Parties for Step 3 are to:

Provide a detailed pre-construction Safety Report that includes sufficient information for the GDA Step 3 Safety and Security Review, in particular:

1. Definition of the documentary scope and extent of the safety case.

2. Explanation of how the decisions regarding the achievement of safety functions ensure that the overall risk to workers and public will be ALARP.

3. Responses to any issues outstanding from GDA Step 2.

4. Sufficient information to substantiate the claims made in GDA Step 2 (in the Preliminary Safety Report).

5. Sufficient information to enable HSE Nuclear Directorate to assess the design against all relevant SAPs.

6. A demonstration that the detailed design proposal will meet the safety objectives before construction or installation commences, and that sufficient analysis and engineering substantiation has been performed to prove that the plant will be safe.

7. Detailed descriptions of system architectures, their safety functions and reliability and availability requirements.

8. Confirmation and justification of the design codes and standards that have been used and where they have been applied, non-compliances and their justification.

9. Fault analyses including Design Basis Analysis, Severe Accident Analysis and PSA.

10. Justification of the safety of the design throughout the plant's life cycle, from construction through operation to decommissioning, and including on-site spent fuel and radioactive waste management issues.

11. Identification of potentially significant safety issues raised during previous assessments of the design by overseas nuclear safety regulators, and explanations of how their resolution has been or is to be achieved.

12. Identification of the safe operating envelope and the operating regime that maintains the integrity of the envelope.

13. Confirmation of:
    (a) which aspects of the design and its supporting documentation are complete and are to be covered by the Design Acceptance Confirmation;
    (b) which aspects are still under development and identification of outstanding confirmatory work that will be addressed during GDA Step 4.

# References

1 *Nuclear power station generic design assessment – Guidance to Requesting Parties* (Version 3) HSE August 2008 www.hse.gov.uk/nuclear/reactors/design.pdf

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3 *The licensing of nuclear installations* HSE www.hse.gov.uk/nuclear/notesforapplicants.pdf

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6 *UK EPR Pre-Construction Safety Report*, UK EPR-0002-132 Issue 02, EDF and AREVA, June 2009. www.epr-reactor.co.uk

7 *Quality assurance for safety in nuclear power plants and other nuclear installations. Code and safety guides Q1 – Q14* IAEA Safety Series No. 50C/SG-Q IAEA 1996

8 *Public Report on the Generic Design Assessment of New Nuclear Reactor Designs. Update on the Public Involvement Process for GDA Step 3 of the Generic Design Assessment Process* HSE GDA-007 November 2009 Available via HSE web-site: www.hse.gov.uk/newreactors

9 *New nuclear power stations generic design assessment -strategy for working with overseas regulators* HSE NGN04 March 2009 www.hse.gov.uk/newreactors/ngn04.pdf

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