Office for Nuclear Regulation

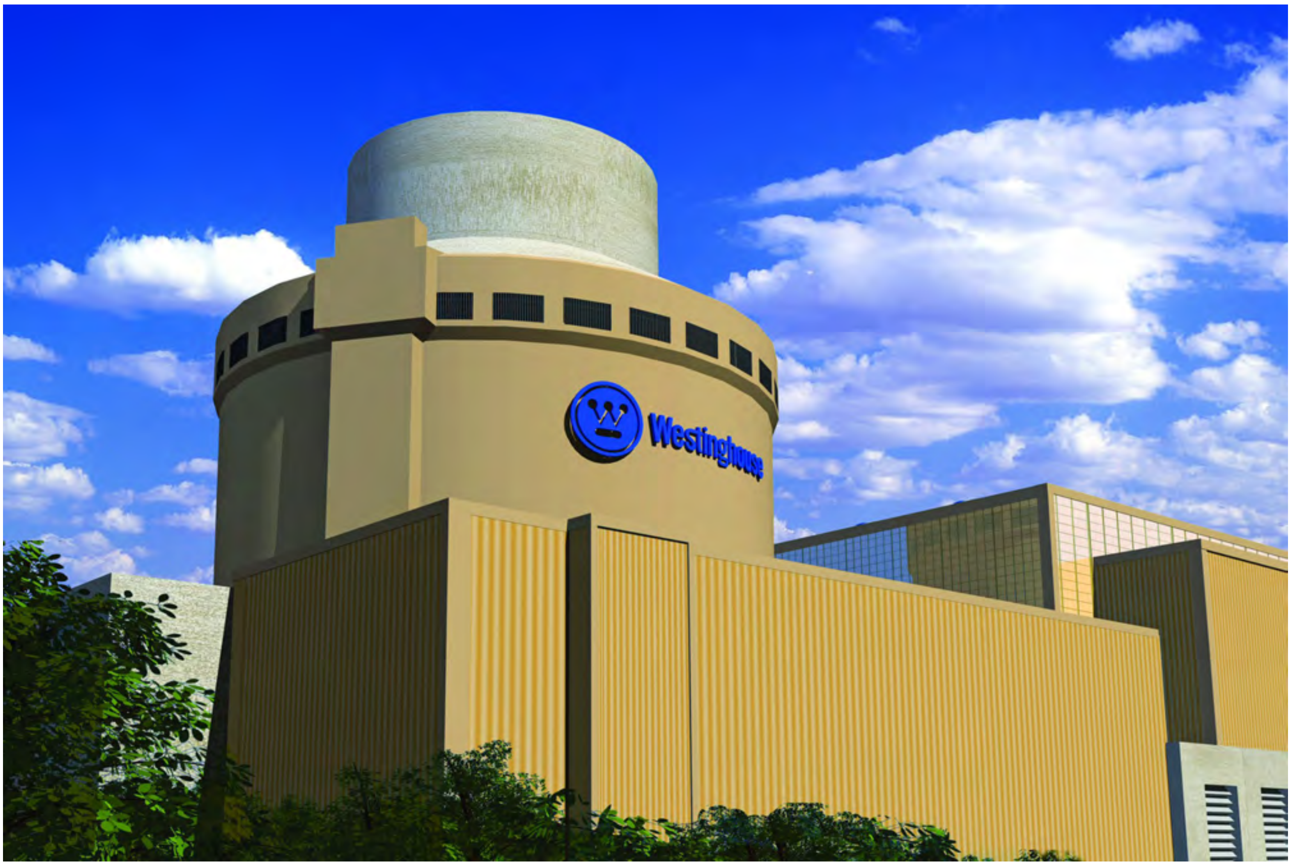
An agency of HSE

New nuclear reactors: Generic Design Assessment

Westinghouse Electric Company LLC AP1000® nuclear reactor

Summary of the detailed design assessment of the Westinghouse Electric Company LLC AP1000® nuclear reactor (Step 4 of the Generic Design Assessment process)

14 December 2011



Report by the Office for Nuclear Regulation on the Generic Design Assessment of new nuclear reactor designs

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Foreword

I am pleased to present this report which summarises the findings of the Office for Nuclear Regulation (ONR) from Step 4 of its Generic Design Assessment (GDA) of the AP1000® reactor. This is our third summary report since we started the Generic Design Assessment (GDA) process in 2007. We are publishing these documents as part of our commitment to be open and transparent about our work. This report, together with a series of more detailed supporting technical reports, provides the main conclusions of our planned GDA assessment. It does not directly address the lessons from the accident at Fukushima as that occurred after the Step 4 submissions were provided to us and the scope of the Step 4 technical assessment reports therefore did not include Fukushima. However, we have ensured that we will address the lessons from Fukushima by including this as a specific GDA Issue (see below).

GDA enables the nuclear regulators to get involved at an early stage in the development of proposals for new nuclear power stations. It allows the technical assessments to be conducted before commitments are made to construct the reactors, meaning that regulatory questions and challenges can be addressed while the designs are still "on paper". The conclusions of this report demonstrate that we have achieved this objective. A number of safety improvements have been identified as a result of our assessment and these are being incorporated into the design long before any construction work starts at a UK site.

We have completed a significant amount of work in our assessment of the AP1000 reactor, and Westinghouse has worked hard to close out many of the technical questions we have raised. We have concluded that we are largely satisfied with the design and safety cases presented to us by Westinghouse for the AP1000 reactor, although some issues remain and require further work.

At a late stage in our Step 4 assessment the accident at Fukushima occurred. The key impact on GDA was that we did not believe it was appropriate to draw conclusions from our assessment work in June 2011 as originally planned, nor publish our GDA technical assessment reports, until the lessons learnt from Fukushima emerged. In effect, our assessment was extended to await the HM Chief Inspector of Nuclear Installations' report on the implications of Fukushima. We also introduced an additional GDA Issue to take account of the Fukushima lessons learnt work. The Chief Inspector's report has now been issued and Westinghouse has provided a resolution plan for the Fukushima GDA Issue, including a description of how it will address the Chief Inspector's report's recommendations

Our original GDA guidance indicated that some issues might remain at the end of Step 4, and this has indeed proven to be the case. Even though we are largely satisfied with the design and safety cases presented to us by Westinghouse for the AP1000 reactor, we have 51 GDA Issues remaining which must be addressed before we will declare that GDA is "complete". We published these issues, together with the industry's resolution plans in July 2011, apart from the plan for responding to the Fukushima GDA Issue, which is now being published alongside this report. These GDA Issues should not be interpreted as a negative regulatory view of the AP1000 reactor design. Rather, they should be seen as evidence of the operation of an independent and robust regulatory process and a demonstration of our mission of securing the protection of people and society from the hazards of the nuclear industry. By carrying out such a robust and transparent assessment, we aim to ensure that any new nuclear power station based on the AP1000 reactor will be safe, secure and – through our colleagues in the Environment Agency – environmentally acceptable.

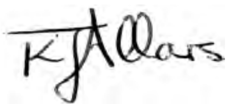
As we are largely satisfied, we have decided to issue an interim Design Acceptance Confirmation (DAC) for the AP1000 reactor. The interim DAC does not in itself permit any additional action in terms of nuclear power station construction, but it does signify that a major milestone has been achieved in that we have reached the end of our planned assessment. It also means that our further assessment work will be targeted on the remaining GDA Issues and will be progressed in accordance with the resolution plans that Westinghouse has provided to us, and that we have accepted as credible. When the GDA Issues have been addressed to our satisfaction we should be in a position to consider issue of a final DAC. Until that time, no nuclear island safety-related construction of a power station based on the AP1000 reactor will be permitted.

A feature of GDA has been the programme and administration arrangements that we put in place to ensure efficiency and joint working between ONR and the Environment Agency. All correspondence and contacts have been managed through a single Joint Programme Office and this has proven to be particularly effective. We have also made extensive use of programme working; we have published plans and performance metrics; and we have placed around 150 support contracts to further bolster the specialist analytical resources available to us.

From the outset we have been committed to conducting GDA in an open and transparent manner and we believe we have achieved this. We have published much information on our websites including regular technical and progress reports, and the Requesting Party safety cases have been published on their websites. We have invited public comment on these and we have also attended and spoken at many events throughout GDA to publicise our work.

Along with the assessment of the UK EPR™ design, this is the first application of GDA. As such, there have been some "teething" problems and completion of Steps 1 to 4 has taken over four years, which is longer than originally envisaged. The reasons for this are diverse and include a lack of ONR resource in the early stages, the spreading of this resource to assess four reactor designs in parallel until Step 3, and difficulties in getting the Requesting Parties to understand the UK regulatory approach and safety case requirements. Despite these factors, GDA is accepted by industry and government to have been a success. Nevertheless, we will review the lessons learnt to help us make improvements for any future GDA projects and to inform the developing improvements in ONR.

If you have any comments on this report I will be pleased to hear from you.



Kevin Allars
Director for Nuclear New Build
Office for Nuclear Regulation
An agency of the Health and Safety Executive
December 2011

Executive summary

This is our third summary report on the AP1000 reactor and it provides our findings at the end of GDA Step 4. This report is supported by a series of detailed technical reports, and together these provide the main conclusions of our planned GDA assessment. It does not directly address the lessons from the accident at Fukushima as that occurred after the Step 4 submissions were provided to us and the scope of the Step 4 technical assessment reports therefore did not include Fukushima. However, we have ensured that we will address the lessons from Fukushima by including this as a specific GDA Issue (see below).

We have also published reports on the outcome of GDA Step 2, the fundamental safety review, in March 2008 and on the outcome of GDA Step 3, the overall design safety and security review, in November 2009. This Step 4 report is on the detailed design assessment – although it also provides an overview of the overall GDA project through Steps 1, 2 and 3.

In addition, since May 2009, we have published a series of quarterly reports. These have described progress, identified key issues, and provided our views on the anticipated position at the end of Step 4.

The aim of GDA Step 4 was to provide a detailed design assessment of the AP1000 reactor, and specifically to:

- move from the system level assessment of Step 3 to a fully detailed examination of the evidence, on a sampling basis, given by the safety analyses;
- confirm that the higher level claims such as system functionality are properly justified;
- assess the conceptual security arrangements for the reactor; and
- complete sufficient, detailed, assessment to allow us to come to a judgement on whether a DAC can be issued.

To achieve these aims, ONR has undertaken an in-depth assessment of the generic design safety case and conceptual security arrangements. Plans were developed for each technical area to set out a strategy for our assessment based on a systematic sample of the information provided by Westinghouse. We have completed a substantial amount of work in our assessment of the AP1000 reactor, expending around £23m of effort, which has included around £7.5m worth of technical contract support. Westinghouse has provided us with over 2700 documents; we have posed over 1500 formal technical questions, and held 400 technical meetings. Westinghouse has worked hard to close out many of the technical questions we raised. We are thus confident that we have completed a meaningful assessment of the AP1000 reactor. This work has been completed well before the start of any AP1000 reactor power station construction project.

The conclusions in this report represent the end of our planned GDA assessment, and the end of GDA Step 4. We have concluded that we are largely satisfied with the safety and security aspects of the AP1000 reactor generic design that have been presented to us by Westinghouse, and we believe that the AP1000 reactor could be suitable for construction on licensed sites in the UK. We have also concluded that there are a number of GDA Issues remaining that must be addressed before we can declare that GDA is "complete".

Westinghouse has produced a resolution plan for each of the GDA Issues and we have reviewed these and judge them to be credible. In recognition of this, and in accordance with our published guidance (Reference 1) we have decided to issue an interim Design Acceptance Confirmation

(DAC) that references these GDA Issues. When the GDA Issues are addressed to our satisfaction, and the safety case is updated and assessed, then we should be in a position to consider issue of a final DAC. Until that time, no nuclear-island safety-related construction of a nuclear power station based on an AP1000 reactor will be permitted.

The interim DAC does not in itself permit any additional action in terms of nuclear power station construction, but it does signify that a major milestone has been achieved in that we have reached the end of our planned assessment. It also means that our further assessment work will be targeted on the GDA Issues and will be progressed in accordance with the resolution plans that Westinghouse has provided to us, and that we have accepted as credible.. Some of these GDA Issues may be resolved with additional safety case changes while others may require design changes. We will summarise our progress on these in our quarterly reports, which we will continue to place on our website and we will also publish a final report to summarise this work should we decide that it is appropriate to issue a DAC at some point in the future.

Office for Nuclear Regulation

In 2008, the Government commissioned a major review into the UK's nuclear regulatory regime. This review was conducted by Dr Tim Stone, senior adviser on nuclear new build to the Secretary of State for Energy and Climate Change and to the Chief Secretary of the Treasury.

Dr Stone made a number of recommendations, which included the need to restructure what was the nuclear regulatory body, the Nuclear Directorate (ND). He proposed the creation of a new, sector-specific regulator for the nuclear industry – the Office for Nuclear Regulation.

ONR was established by HSE on 1 April 2011, signalling the commitment to securing an appropriately resourced and responsive regulator for the future challenges of the nuclear sector. ONR has been set up as an agency of HSE, pending planned legislation to establish it as a statutory body. It has now brought together the relevant nuclear regulatory functions of HSE (through its Nuclear Directorate) and the Department for Transport (DfT).

The functions, structure and future plan for ONR are set out in our Corporate Plan, which can be found on our website at www.hse.gov.uk/nuclear/corporate-plan-2011-2015.pdf. The plan identifies the outcomes we must deliver, our core activities, and the breadth of activities that we will undertake to achieve those outcomes.

In this report we therefore generally use the term “ONR” for our organisation, except where we refer back to documents or actions that originated when we were still HSE’s Nuclear Directorate.

Contents

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 and arrangements to be made to control the activities on the site in accordance with the Conditions that are attached to the licence. Permission must be given under these Licence Conditions 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 by ONR, after assessment of the application, to a corporate body (e.g. an operator) to use a site for specified activities. In doing this we also look at the siting and organisational factors. The site licence with the attached 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 (the Office for Nuclear Regulation – ONR – and the Environment Agency) developed a revised assessment process for new nuclear power stations. This led to the production of guidance on the Generic Design Assessment (GDA) process, which was originally published in January 2007: *Nuclear power station generic design assessment – guidance to requesting* parties (Reference 2) and *Guidance document for generic design assessment activities* (Reference 3).

The updated arrangements are based on a two-phase regulatory assessment process which separates the GDA from the site-specific ONR licensing assessment and Environment Agency permitting process. Phase 1, GDA, is a rigorous and structured examination of the generic safety and security features of the reactor design and is undertaken independently of any site-specific assessment, although the two could overlap.

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 ONR to ensure a full understanding of the requirements and processes that would be applied, and to arrive at formal agreements to allow ONR to recover its costs from the Requesting Party. Step 1 commenced in July 2007 and completed in August 2007.
- 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 acceptable for construction in the UK. Step 2 commenced in August 2007 and completed in March 2008, when we published a series of reports on our work. These are listed in Annex 2.
- 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 arrangements are laid through dialogue with the Requesting Party. Step 3 commenced in June 2008 and completed in November 2009 with the publication of a series of reports on our work. These are listed in Annex 2.

- GDA Step 4 is a detailed design review and is intended 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 also examines the proposed conceptual security arrangements. If the generic design is considered acceptable, a DAC could be issued at the end of GDA Step 4. Step 4 commenced in November 2009 and has been completed with the publication of this report.

Initially, four reactor designs were accepted for GDA, and work on Step 1 on each began in July 2007. The designs were:

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

In April 2008, following Step 2, Atomic Energy of Canada Limited withdrew the ACR-1000 reactor from GDA and in June 2008 we began GDA Step 3 on the remaining three designs. In September 2008, GE-Hitachi requested that assessment work on the ESBWR reactor be suspended and we therefore continued to progress GDA Step 3 on the UK EPR™ and AP1000 reactor designs only.

The step-wise assessment approach to GDA allowed us to look in increasing detail at the safety and security issues as we progressed through the various steps. It enabled us to start with a fairly small assessment team and to grow this as we moved through the project. In parallel with our work on safety and security aspects the Environment Agency examined the potential environmental impact.

Phase 2 of the new build regulatory assessment process, will involve an applicant seeking Permits from the Environment Agency and a nuclear site licence from ONR. Therefore, in Phase 2, ONR 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. Subsequently, before construction of a reactor can commence, permission to start the construction must be obtained from ONR under the conditions attached to the site licence.

More information on the licensing process can be found in the publication *The licensing of nuclear* installations (Reference 4).

The Energy Act 2011 contains an enabling power for the Government to make regulations on the security of civil nuclear sites including power stations while they are being constructed, and before a site licence is granted. DECC intends to make regulations in 2012 on security at civil nuclear construction sites using these new powers and existing ones in the Anti-terrorism, Crime and Security Act 2001. ONR (CNS) will use these powers to regulate security aspects of new build activities from the start of significant civil works.

The expectation is that any DAC provided to Westinghouse would be carried forward from GDA by the future nuclear licensee to support the Phase 2 site-specific work and, in particular, ONR's assessment of whether to permit nuclear-island safety-related construction. It is our intention that we will not reassess aspects covered by the DAC except, of course, to address any significant changes to the safety case, any new developments, site-specific elements, or design changes proposed by the future operator (Reference 1).

It should be noted that Phase 1 GDA and Phase 2 site specific work can overlap. In these cases, it is our current intention that a DAC will be required, before permission to begin nuclear island safety-related construction will be given, but not necessarily before a site licence is granted. Ultimately, a DAC can be used to underpin the permissions required from ONR to construct a fleet of identical reactors, except for site or operator-specific changes.

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.

GDA 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 has been encouraged to comment on the reactor designs and we have considered these comments, along with the responses from the designers, within our assessment.

On 11 March 2011 the accident at Fukushima occurred. On 14 March 2011 the Secretary of State for Energy and Climate Change requested HM Chief Inspector of Nuclear Installations to examine the circumstances of the Fukushima accident to see what lessons could be learnt to enhance the safety of the UK nuclear industry. The key impact on GDA was that we did not believe it was appropriate to draw conclusions from our assessment work in June 2011 as originally planned, nor publish our technical findings, until the lessons learnt from Fukushima had emerged and been considered by ONR and the Requesting Parties. In effect, our assessment was extended by several months to await the Chief Inspector's report on the implications of Fukushima.

The scope of the Step 4 technical assessment reports did not include Fukushima as the accident occurred after the Step 4 submissions were provided to us. However, we have ensured that we will address the lessons from Fukushima by including this as a specific GDA Issue.

The Chief Inspector's report was published on 11 October 2011 and Westinghouse has provided a resolution plan for the Fukushima GDA Issue, including a description of how it will address the Chief Inspector's report's recommendations. ONR will continue to assess their progress on this matter and closure of the GDA Issue will be required, alongside closure of all the other GDA Issues, before GDA could be considered complete.

A timetable of key events in GDA is included in Annex 1 of this report.

Introduction

The role of ONR is to secure the protection of 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* 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 those 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 GDA Step 3, the overall design safety and security review, was completed in November 2009. We published a series of reports summarising our work and, in each of these steps, concluded that we had found no shortfalls that would rule out eventual construction of these reactors on licensed sites in the UK. These reports are listed in Annex 2.

This report is on GDA Step 4 of our assessment of the Westinghouse AP1000 reactor, the detailed design assessment, and it covers the period from November 2009 to the summer of 2011. The aim of GDA Step 4 was to provide an overall detailed assessment of each design submitted – in this case the AP1000 reactor – and, specifically, to:

- move from the system level assessment of Step 3 to a fully detailed examination of the evidence, on a sampling basis, given by the safety analyses;
- confirm that the higher level claims such as system functionality are properly justified;
- assess the conceptual security arrangements for the reactor; and
- complete sufficient, detailed, assessment to allow us to come to a judgement whether a DAC can be issued.

To achieve these aims, ONR has undertaken an in-depth assessment of the safety case and the generic site envelope. From a security perspective, we have examined the conceptual security arrangements.

In this report we describe the work we have completed and the issues that have emerged, and we summarise the conclusions of our assessment. To help manage our work, we have split it into 15 technical topic areas, plus the security topic, 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 technical topic areas) which describe 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 at www.hse.gov.uk/newreactors.

* 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.

ONR expectations for modern reactors

ONR will require any nuclear reactor that is built in the UK to be of a robust design that provides adequate protection against potential accidents to a degree that meets modern international good practice. This means we will assure ourselves that the potential risk from the operation of such a reactor in the UK has been reduced to “as low as is reasonably practicable” (ALARP).

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, or from human errors. ONR 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 shut down the reactor and stop the nuclear chain reaction; the ability to cool the shut-down reactor; and the ability to contain radioactivity.

The adequacy of protection provided needs to be demonstrated by a comprehensive safety analysis that examines all the faults and hazards that could threaten the reactor. This must show that the reactor design is sufficiently robust to tolerate these faults and hazards, and that it operates with large margins of safety. ONR 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 back-up systems and other safety features can be provided. This multi-barrier protection concept has to be applied repeatedly until the risk of an accident is acceptably low.

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

ONR expectations from the GDA process

Details of ONR's expectations for the GDA process as a whole, and specifically for GDA Step 4 of the GDA process, can be found in the GDA guidance (Reference 2). For the completeness of this report a key section of that document, which describes what ONR expects from a Requesting Party for GDA is summarised in Annex 3.

Details of the expectations of the Office for Civil Nuclear Security (OCNS), now part of ONR – ONR(CNS) – for GDA Step 4 can be found in the ONR(CNS) guidance (Reference 3). In summary, the expectation is that a Requesting Party would provide sufficient information to enable ONR(CNS) 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 GDA Step 4 assessment ONR has undertaken of the information gathered from Westinghouse to address the points listed in Annex 3.

The safety standards and criteria used

The main document used for the GDA Step 4 assessment was the 2006 edition of our SAPs (Reference 5). 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).

Management of GDA outcomes

Our original GDA guidance (Reference 2) indicated that some technical issues might remain at the end of Step 4 but it didn't provide much information about how these issues would be managed. We therefore published, in June 2010, additional guidance on the management of GDA outcomes (Reference 1) to provide clarity on how any remaining issues would be handled during the ongoing design, procurement, construction and commissioning phases of a power station based on the assessed generic design.

This guidance identified that there could be three potential outcomes at the end of Step 4:

1) If we were fully content with the generic safety and security aspects then we would provide the Requesting Party with a DAC which would mark the end of GDA for that generic design.

2) If we were largely content with the generic safety and security aspects then we would provide the Requesting Party with an interim DAC and identify the unresolved GDA Issues. These issues would need to be cleared before a final DAC could be provided or before we could consider granting permission for the start of nuclear island safety-related construction for a power station based on that design.

3) If we were not content with the generic safety and security aspects then no DAC would be issued.

In this report we review our GDA assessment results for the AP1000 reactor and conclude that outcome 2, above, is appropriate, and that an interim DAC can be issued.

GDA Issues and resolution plans

GDA Issues were defined in Reference 1 as follows:

> *Unresolved issues considered by regulators to be significant, but resolvable, and which require resolution before nuclear island safety-related construction of such a reactor could be considered.*

In this report, we identify the GDA Issues for the AP1000 reactor at Annex 4.

For each GDA Issue, Reference 1 requires that the Requesting Party would need to provide a resolution plan to demonstrate that the issue is resolvable. We would have to accept that each resolution plan is credible before coming to a decision to issue an interim DAC. In this report we list at Annex 4 the resolution plans that Westinghouse has provided.

The GDA Issues and resolution plans have also been published on our website at www.hse.gov.uk/newreactors.

Interim Design Acceptance Confirmation

Provision of the interim DAC for the AP1000 reactor means that we are confident that the design is capable of being built and operated in the UK, on a site bounded by the generic site envelope, in a way that is safe and secure. However, it also means that there are some GDA Issues remaining that need to be addressed to our satisfaction before nuclear-island safety-related construction of that reactor could commence.

Design Acceptance Confirmation

Once all the resolution plans are completed and GDA Issues addressed satisfactorily, and the safety case updated, we will consider whether a final DAC could be issued.

Assessment Findings

GDA was designed to assess the generic safety case for future reactor designs, it was not intended to provide a complete assessment of the final reactor design, as there will be other factors, operator specific or site specific, that we would expect to be considered during the site specific stages. Also, in some instances, final validation of the safety case can inevitably only be completed when the final detailed design of equipment is developed by a manufacturer / supplier, or when the facility is being constructed and is in the process of being tested. This validation process is normal regulatory business and will be subject to appropriate regulatory controls.

The generic safety case that forms the basis of the GDA submission will inform any site-specific safety case and it therefore follows that our GDA assessment will inform our site-specific assessment. Part of the link from GDA to site-specific assessment is assured by identification of GDA Assessment Findings, which are defined in Reference 1 as follows:

> *Findings identified during the regulators' GDA assessment that are important to safety, but not considered critical to the decision to start nuclear island safety-related construction of such a reactor.*

The Assessment Findings arising from our GDA assessment for the AP1000 reactor are identified in the detailed Step 4 assessment reports for each technical topic area. We expect these to be addressed either by the designer or by a future Operator / Licensee, as appropriate, during the detailed design, procurement, construction or commissioning phase of the new build project.

Management of the GDA process

GDA is a new process which was devised during 2006 and commenced in 2007. We have implemented a number of new ways of managing our work, some of which are described below.

Guidance documents

We developed and published a number of guidance documents to assist Requesting Parties to understand our expectations for the GDA process and the UK regulatory regime. The main guidance documents produced are:

- GDA guidance – HSE and ONR(CNS), References 2 and 3
- Top-level guide for regulator joint working, Reference 6
- Management of GDA outcomes, Reference 1
- Assessment in an international context, Reference 7
- Strategy for international input into GDA, Reference 8
- Radioactive waste guide for GDA, Reference 9

These supplement and build on guidance already in the public domain, available via the ONR website, principally our Safety Assessment Principles and their supporting Technical Assessment Guides (TAG).

Joint working with the Environment Agency using the Joint Programme Office

GDA was designed to allow the Nuclear Regulators (ONR and the Environment Agency) to work closely together. In support of this we set up a Joint Programme Office (JPO), which administers the GDA process on behalf of both Regulators, providing a "one-stop shop" for the assessment of potential new nuclear power stations. Both ONR and the Environment Agency used a common process for receiving GDA submissions, for correspondence, and for raising and tackling technical matters. We believe this has improved efficiency both for the nuclear regulators and the Requesting Parties.

Technical Queries, Regulatory Observations and Regulatory Issues

To help us to effectively track the progress of our assessments and our technical interactions with Requesting Parties in an auditable way, we introduced a tiered system to reflect the importance of information and technical issues which emerge during the GDA process. In increasing order of importance these are:

Technical Queries: These were the means by which we routinely sought clarification or further technical information from the Requesting Party. Typically this might be a request for supporting documentation or other clarification of claims or arguments made by a Requesting Party in their safety case. A Technical Query may have resulted in a Regulatory Observation or Regulatory Issue being raised where the query was not satisfactorily resolved.

Regulatory Observations: We used Regulatory Observations to bring significant assessment matters to the attention of a Requesting Party, to highlight that further justification was required. Regulatory Observations were supplemented by one or more actions which set out our expectations for the work required. The Requesting Party response was then the subject of further assessment by the regulators.

Regulatory Issues: We used Regulatory Issues to identify matters that we considered were of sufficient importance that they may, if not resolved, have prevented the successful completion of GDA. Regulatory Issues were supplemented by one or more actions which set out our expectations for the work required for a satisfactory resolution. Their response was then the subject of further assessment by the regulators.

Technical Support Contractors

We placed work packages with contractors to help us carry out our detailed technical assessment. We established a framework agreement, including 31 Technical Support Contractors (TSC) 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 regulatory assessment. However, all regulatory decisions are made by the nuclear regulators – not by contractors.

The scale and timeframe of GDA meant that we utilised significant additional technical support to assist our work. We placed over 150 separate contracts under this framework in support of GDA, at a cost of around £15m, of which around half have been in support of our work on the AP1000 reactor.

Resourcing

In 2007, we set up a specific GDA programme assessment team separate from other assessment demands in ONR. This helped their focus on GDA. Due to recruitment difficulties, we were unable to fully resource the team at the outset and this led to the need for some back-end loading, where we used additional staff to help minimise overall timescales, while ensuring we completed a robust and timely assessment.

Programme and project management

We introduced dedicated professional project managers to help co-ordinate and progress GDA. This improved the degree of planning and monitoring on the project and had a positive effect on helping ensure programme objectives were achieved. We are now introducing a programme management approach for much of our work in ONR.

Openness and transparency

We conducted GDA in a spirit of openness. We have published reports of our work at key stages, as well as regular reports of progress that have included performance metrics. Westinghouse has published its safety submissions on its website and has engaged in the public comment process that we set up for GDA. Further details are given in the relevant section of this report.

Addressing the accident at Fukushima

On 11 March 2011 Japan suffered its worst recorded earthquake. Reactor Units 1, 2 and 3 on the Fukushima Dai-ichi (Fukushima-1) site were operating at power before the event and on detection of the earthquake shut down safely. Within an hour a massive tsunami from the earthquake inundated the site. This resulted in the loss of all but one diesel generator, some Direct Current (DC) supplies and essential instrumentation, and created massive damage around the site. Despite the efforts of the operators, eventually back-up cooling was lost. With the loss of cooling systems, Reactor Units 1 to 3 overheated. This resulted in several explosions and what is predicted to be melting of the fuel in the reactors leading to major releases of radioactivity, initially to air, but later by leakage of contaminated water to sea.

On 14 March 2011 the Secretary of State for Energy and Climate Change requested that HM Chief Inspector of Nuclear Installations examine the circumstances of the Fukushima accident to see what lessons could be learnt to enhance the safety of the UK nuclear industry. The Secretary of State requested HM Chief Inspector to provide an interim report by the middle of May 2011, with a final report six months later. The interim report (Reference 10) was published on 18 May 2011 and the final report on 11 October 2011 (Reference 11).

The key impact on GDA is that, as we were waiting for any lessons learnt from Fukushima to emerge in the final report, we did not believe it was appropriate to draw conclusions from our GDA assessment work in June 2011 as originally planned, nor publish our GDA technical assessment reports on that date. In effect, our assessment was extended to await the recommendations of HM Chief Inspector's reports.

The interim and final reports identify the implications for the UK nuclear Industry and set out a number of recommendations for the UK Government, the UK Nuclear Regulator and the UK nuclear industry to address. In total, there are 38 recommendations, one of which has been completed, four of which are relevant to the Regulator, 23 of which are relevant to the nuclear industry and nine of which are generally relevant to the UK Government, the Regulator and the nuclear industry. The final recommendation requires reports of progress responding to the recommendations to be made to ONR by June 2012.

In an international context there are a number of ongoing initiatives:

- The European Nuclear Safety Regulatory Group (ENSREG) has defined a set of "Stress Tests" to be carried out in European member states for nuclear power plants in operation or being constructed. Each member state will report the outcome of the "Stress Tests" by the end of December 2011, and these reports will be peer reviewed in early 2012 by an expert panel drawn from European member states.
- IAEA has initiated a number of activities to draw lessons from the accident, assist the Japanese authorities and report to IAEA member states. These include:
    - A preliminary mission to find facts and identify initial lessons to be learnt, undertaken by a team of experts from across the world, conducted from 24 May to 2 June 2011.
    - An IAEA *Action plan on nuclear safety*, which is aimed at making nuclear safety post-Fukushima more robust and effective.
    - An extraordinary meeting of the Convention on Nuclear Safety to share lessons learnt and actions taken in response to events at Fukushima, to be held in August 2012.

The scope of the Step 4 technical assessment reports did not include Fukushima as the accident occurred after the Step 4 submissions were provided to us. So, to ensure that the lessons learnt from the Fukushima accident are considered within GDA, we raised a further GDA Issue on Westinghouse to address any lessons to be learnt for the generic AP1000 reactor design. This GDA Issue requests Westinghouse to demonstrate how they will take account of the lessons learnt from the events at Fukushima, both those arising out of Westinghouse's own internal reviews as well as those lessons and recommendations identified in HM Chief Inspector's interim and final reports. These should also take account of the wider international initiatives.

Westinghouse has provided a resolution plan for this Fukushima GDA Issue, including a description of how it will address the Chief Inspector's report's recommendations and we judge that this is credible. We will continue to assess its progress on this matter and closure of the GDA Issue will be required, alongside closure of all the other GDA Issues, before GDA could be considered complete.

Main features of the AP1000 reactor design and safety systems

The AP1000 reactor, as proposed to us by Westinghouse, is described in the Westinghouse December 2009 *AP1000 Pre-construction Safety Report* (PCSR*),* Reference 12.

Westinghouse describes the AP1000 reactor as a pressurised water reactor based closely on the AP600 design which, although it achieved US Nuclear Regulatory Commission (US NRC) design certification, was never constructed. The AP1000 reactor maintains the AP600 configuration and the US licensing basis by limiting the design changes. It has a claimed operational design life of 60 years and a nominal gross electrical output of approximately 1100 MWe (actual power output depends on site-specific conditions). In comparison to other pressurised water reactors the design includes novel passive safety features and extensive plant simplifications that Westinghouse claims enhance the safety, construction, operation and maintenance of the plant.

The AP1000 reactor comprises a steel Reactor Pressure Vessel (RPV) and two heat transfer circuits, each with a single hot leg and two cold legs, a steam generator, and two reactor coolant pumps installed directly into each steam generator. The pressure vessel is cylindrical with a hemispherical bottom head and removable flanged hemispherical upper head. It is approximately 12m long with an inner diameter of approximately 4m, and has a design life of 60 years.

The reactor core is comprised of 157 fuel assemblies, 4.26m long, each with a 17 x 17 matrix of fuel pins containing 2.35–4.95% enriched U^{235}. Refuelling is carried out off-load, and the core is designed for a fuel cycle of 18 months with a 93% capacity factor, and region average discharge burn-ups up to 60,000MWd/t.

Westinghouse claims that the AP1000 reactor 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 Westinghouse are:

Reactor shutdown

- The **reactivity control system**, which Westinghouse claims provides the means to trip the reactor, maintains a safe shutdown condition, and control reactivity in the event of certain anticipated events. It comprises the protection and safety monitoring system, plant control system, diverse actuation system, reactor control rods and boration of the reactor coolant.

Emergency cooling

- Passive "safety-related" systems operate in the unlikely event of an accident and consist of:
  - a **Passive Core Cooling System (PCCS)**, which uses three passive sources of water that Westinghouse claims will maintain core cooling through safety injection. The injection sources include the core make-up tanks, the accumulators and the In-containment Refuelling Water Storage Tank (IRWST). In addition, after injection of these water supplies, Westinghouse claims long-term containment recirculation can be provided by natural convection-driven flow;
  - a **Passive Containment Cooling System (PCS)**, which provides the ultimate heat sink for the plant. This is a gravity-fed cooling water delivery system connected to the passive

containment cooling water storage tank mounted on the reactor building roof that provides an even flow of water over the surface of the containment. Westinghouse claims this system cools the containment so that the pressure is rapidly reduced and the design pressure is not exceeded. The steel containment vessel provides the heat transfer surface and heat would be removed from the containment vessel by continuous natural circulation of air; and

- the **Main Control Room emergency habitability system**, which provides fresh air, cooling and pressurisation to the Main Control Room to prevent it becoming contaminated in accident scenarios.

- Westinghouse claims that the passive safety systems require no operator actions to mitigate design-basis accidents and, once activated, work using only natural forces (e.g. gravity, natural circulation or expansion of compressed gas). They are activated by the operation of a few valves and Westinghouse claims they are designed to meet the single-failure criterion, and to support Probabilistic Risk Analysis (PRA) safety goals.

Containment

- The reactor shield building is composed of novel design Steel-Concrete-Steel (SCS) sandwich sections. Within the shield building is the steel containment vessel which provides a continuous, pressure-retaining, envelope around the primary circuit heat transport systems. Westinghouse claims that a containment isolation system will ensure that the relevant penetrations are closed.

Retention of molten core debris

- Westinghouse claims that in a core damage event where the core has uncovered and overheated, water will flood the outside of the reactor vessel and prevent vessel failure, thus retaining any molten core debris. The water is sourced from the IRWST, provided either by normal post-accident operation of the passive safety systems or operator-initiated draining of the tank.

Summary of AP1000 reactor GDA safety and security submissions

A key aim of this report is to provide a summary of the assessment of the information ONR has gathered from Westinghouse during GDA Step 4 to address the points listed in Annex 3, which describes what ONR expects from a Requesting Party for GDA Step 4.

The information provided by Westinghouse for GDA is presented in a number of documents including the GDA Design Reference and the GDA Safety, Security and Environment Submissions. The key documents for ONR's assessment include the generic Pre-construction Safety Report (PCSR), the Design Reference (DR) and the Master Submission List (MSL). These are described below.

Generic Pre-construction Safety Report

Westinghouse's safety case was described in its December 2009 PCSR, which was submitted at the beginning of Step 4 (Reference 12). This PCSR was rewritten during Step 4 to take account of matters raised during our assessment, and to improve the presentation and coherence of the safety arguments. In our assessment we used Westinghouse's responses to our regulatory questions to make up for many of the gaps and shortfalls in the December 2009 PCSR. A draft revised version was submitted in December 2010 for comment, and finally a formally approved version of this PCSR was submitted on 30 March 2011 (Reference 13), although this was too late to allow assessment within Step 4. It will require assessment in future and this is the subject of a GDA Issue.

Master Submission List

As we progressed through Step 4 we requested submission of a selection of references identified within the PCSR, to allow more detailed information to be examined. In addition, developments in the safety case, design modifications, and responses to regulator assessment questions arose during Step 4. The totality of the GDA submission is listed in the Master Submission List, which includes the documentation sampled by the regulators during GDA.

The MSL supporting the GDA submission up to the end of March 2011 was provided in May 2011 (Reference 14), which was subsequently, in October 2011, converted into a version containing no commercial in confidence information (Reference 15).

Design Reference

Westinghouse was required to submit a Design Reference to list all the documents that describe the design of the AP1000 reactor and associated plant that the GDA submissions refer to. We required this to be "frozen" at a specific date known as the Design Reference Point (DRP).

Westinghouse submitted their first DR in December 2009, but this was not accepted as the basis for GDA as it did not sufficiently define the design. This was subsequently developed and replaced by revised versions as our discussions progressed. The final version of the DR, containing no commercial in confidence information, was submitted in November 2011 (Reference 16) with the DRP date identified as 16 September 2010.

The DR includes over 1500 Design Change Proposals (DCP), many of which have not yet been fully incorporated into the design, safety and other engineering documentation. Our expectation for a final DAC is that Westinghouse will fully implement all the DCPs in the DR by incorporating the change details into all impacted DR documents, and the MSL documentation, including the PCSR.

Out-of-scope items

GDA was designed to assess the generic safety case for future reactor designs, within a generic site envelope, and not the adequacy of a complete design that will be built on a specific site, as there will be operator and site specific factors that can only be considered during the site specific stages.

The scope of GDA includes the containment structure, the nuclear reactor buildings and supporting equipment within the nuclear island (i.e. within the main body of the reactor and auxiliary support buildings, such as diesel houses and fuel storage facilities). It also includes examination of the performance of these structures and components in the face of generic hazards such as earthquakes or airplane crash. It does not, however, include site-specific matters such as the cooling water pumphouse or the sea wall as these will be different at every site and can only be addressed at the site specific stage.

Also, in some instances final validation of the safety case cannot be completed until the final detailed design is developed for a specific site by a future licensee; until certain equipment designs are confirmed by their manufacturers / suppliers; or until the facility is being constructed and is in the process of being tested. In these technical areas the system and equipment safety functions and requirements are set out within GDA and the later validation and provision of additional evidence should underwrite the specifications that were provided in GDA and confirm that they have been achieved. This validation process is normal regulatory business and will be subject to appropriate regulatory controls.

Finally, there are some matters that are out-of-scope, such as the use of MOX fuel, because there is no current UK plan in relation to them.

A breakdown of the items that are out-of-scope is provided within Reference 17**.** Anything that is out-of-scope will need to be addressed, as appropriate, by a future licensee and will be examined by ONR as part of our normal regulatory business during the site specific stage. The impact that the out of scope items have had on our assessment varies between topic areas and key out-of-scope items are identified in each topic area report. Examples of out-of-scope items are as follows:

- The quality assurance arrangements for long lead reactor equipment manufacture, procurement and supply.
- Pre-service and in-service inspection of pressure vessels and primary circuit pipework
- Some aspects of civil engineering detailed design.
- The detailed design of some mechanical and electrical equipment.
- Aspects of detail design and testing of the C&I systems
- Details of the electrical system fast transient analysis.
- Decontamination facilities

- Detail design of radioactive waste processing and storage facilities outside of the nuclear island.
- Load-following (variation of reactor power to respond to national grid demands).
- The use of reprocessed or mixed-oxide (MOX) fuels.
- Mid-loop operations for maintenance activities (operation with the main coolant loops partially drained).

However, it should be noted that the outcomes of GDA may have an impact on some plant areas that have been out-of-scope for GDA. For example, the nuclear safety-related buildings not included in GDA, such as the plant-specific cooling water pumphouses, will still need to take account of the civil engineering construction codes that we have examined in GDA. Future licensees will need to demonstrate that they have considered this as their design and construction plans progress.

Assessment strategy

The aim of GDA Step 4 was to provide an overall detailed design assessment of each design, and this report covers our assessment conclusions for the AP1000 reactor. We have focused on an examination of the safety claims, arguments and evidence for the AP1000 reactor. We have, on a sampling basis, looked at available detailed design level information and analysed the available evidence. Our objective was to ensure that sufficient evidence exists to support Westinghouse's safety arguments and safety claims that we examined in Step 3, and to ensure that it is adequate in the light of our current understanding of reactor technology.

In our GDA Step 4 assessment, we have assessed the safety claims, arguments and evidence as presented in Westinghouse's December 2009 AP1000 PCSR (Reference 13), and supporting documents. We have compared these against the relevant parts of our SAPs (Reference 5). To help us in this task we developed a strategy to define both the technical areas to be sampled and those SAPs most relevant for GDA Step 4, 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 containment of radioactivity.

Specific assessment plans were developed for each technical area. As Step 4 has built upon our work in Steps 2 and 3, we targeted our sampling based on our increasing knowledge of the Westinghouse AP1000 reactor generic design and safety case. The Step 4 assessment plans also took into account the findings of our Step 3 assessment reports, including those technical issues that we had noted, in November 2009, as unresolved.

Some further information on the scope of the Step 4 assessment is given within this report in the summaries for each technical area.

Summary of ONR GDA findings

A significant amount of assessment was completed in GDA Steps 2 and 3. During Step 2 this was fairly limited in scope and depth, concentrating on Westinghouse's high-level safety claims. In Step 3 our assessment was wide ranging, focusing on the safety arguments, and was quite detailed in some topic areas. For some of these topic areas, the assessment of certain aspects was completed. This work is reported in detail in our Step 2 and Step 3 assessment reports, which are listed in Annex 2 and copies of which are available on our website: www.hse.gov.uk/newreactors.

The GDA Step 4 assessment of the AP1000 reactor has been a period of intense activity where both ONR and Westinghouse have expended significant effort.

ONR has used over 23,000 person-days of effort employing around £7.5m worth of technical contract support in the process. Westinghouse has provided us with over 2700 documents; we have posed over 1500 formal technical questions; and, during Step 4 alone, we have held over 400 technical meetings. In some areas we identified significant issues, primarily due to a combination of late delivery of information from Westinghouse and a lack of clarity in the safety arguments and documentation.

Westinghouse has worked hard to close out these issues, and the technical questions we raised, and significant progress was made during Step 4.

The result was that we have been able to complete a wide-ranging, comprehensive, detailed, robust and meaningful assessment of the AP1000 reactor, and this work has been completed well before any AP1000 reactor power station construction project has commenced in the UK.

The sections below summarise the key findings of the GDA detailed generic design and safety case review for each of the technical topic areas. These primarily summarise the work that has been undertaken in Step 4, but for completeness, some topic areas also include findings from Step 3, where these were particularly significant. Full details are given in the individual topic area assessment reports that are listed in Annex 2 and are available on our website: www.hse.gov.uk/newreactors.

Internal Hazards

ONR's safety assessment within this topic includes hazards such as fire, explosion, flood, dropped loads, pressure part failure, and steam release etc. arising within the site boundary. 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, our assessment included the following:

- Dropped loads and impact, high energy line break, internal missile, fire, steam release, internal flooding, and internal explosion.
- Deep slice sampling of the evidence for a number of areas, including common cause failure, pressure part failure, internal explosion, and internal missile generation.

- Progressing those matters we raised during Step 3.

There have been no items identified as being outside the scope of the GDA.

From our assessment, we have concluded:

- There are areas where the safety case presented for internal hazards fails to adequately address the requisite claims, arguments, and evidence and this has resulted in the identification of a number of GDA Issues. In all such areas, Westinghouse has understood our concerns and believes that they are largely attributable to the differing regulatory approaches between the US and the UK.
- Notwithstanding the GDA Issues identified by our assessment, we believe that the AP1000 reactor layout with respect to internal hazards is clear and logical, and one which has been developed through appropriate consideration of standards, guidance, and relevant good practice.
- Throughout Step 4, Westinghouse has adopted a reactive approach to addressing the shortfalls. This led to documentation being produced in response to assessment concerns, and this documentation being supplied in parallel with the assessment. This may also explain some of the inconsistency we have identified within the December 2009 PCSR documentation of the internal hazards safety case. As a result, the GDA Issues should be relatively straightforward to address.
- The quality of the information provided, coupled with the technical exchanges that have taken place during Step 4, has improved significantly from Step 3. Westinghouse now has a far clearer understanding of the UK regulatory regime as well as of the approach taken to safety case production for internal hazards.

There are six GDA Issues in this topic area, related to:

- Substantiation of the barriers in place to prevent fire spread affecting more than one train or division and the need to substantiate fire damper provision.
- Provision of a revised safety case for internal flooding.
- Identification and substantiation of all nuclear significant pipe whip restraints, barriers and shields claimed for the protection of redundant trains against the effects of pressure part failure.
- Provision of substantiation to support claims and arguments made within the area of internal explosion, specifically associated with hydrogen generation within battery rooms and the distribution of hydrogen within areas containing safety equipment.
- Identification and substantiation of the claims, arguments and evidence that constitute the internal missile aspects of the internal hazards safety case.
- Substantiation including supporting analyses of the consequences of dropped loads and impact from lifting equipment included within the AP1000 reactor design.

Civil Engineering and External Hazards

ONR's assessment of the AP1000 reactor civil structures includes consideration of the integrity of structural components such as the nuclear island foundations, concrete structures such as the shield building and operational buildings, and steel structures such as steel-framed buildings.

Our assessment of external hazards includes those natural or man-made hazards that originate externally to the site and over which the operator has little control. External hazards include earthquake, aircraft impact, extreme weather and flooding, and the effects of climate change.

The design codes and methodologies proposed by Westinghouse have been examined in detail during GDA; however the application into site specific structures can only be undertaken during the site specific detail design phase. A further complication for this assessment topic area is the site-dependent nature of both the magnitude of the external hazards and the local conditions that may dictate design choices. As a consequence there are a number of areas where the detailed design cannot be confirmed until the site licensing and construction phase, for example confirmation that the site specific seismic hazard is bounded by the generic site envelope used in GDA.

For GDA, our assessment included the following:

- The design of the novel, steel-concrete-steel composite sandwich, modular construction proposed for the Enhanced Shield Building circular wall, and other civil structural modules (known as CA Modules), and for the Spent Fuel Pool (SFP) area of the Auxiliary Building, including the response to the Regulatory Issue on this topic.
- Metrication of the AP1000 reactor design when used in the UK.
- Materials used in the AP1000 reactor design and their applicability in the UK.
- Safety categorisation and classification of civil structures.
- External hazards claims and dependencies.
- Potential impacts to structures from aircraft or malicious activity.
- The development of the load schedule to be applied to civil structures resulting from external hazards.
- The seismic design methodology and finite element modelling used.
- The application of design and construction codes and standards and industry good practice.
- Deep sample review for a number of structures, including certain parts of the Auxiliary Building, the Shield Building roof, Nuclear Island (NI) foundation slab, SFP, and in-containment CA Modules.
- Control of design quality with respect to Westinghouse's use of sub-consultants or "design partners"; how they are instructed and how their work is checked and approved.

Since the Radioactive Waste Building layout is to be reviewed following re-appraisal of the space required within it, civil engineering assessment of the structure has been agreed with Westinghouse as outside the scope of the GDA process.

At an early stage we identified significant concerns in relation to the adequacy of the novel steel-concrete-steel sandwich modular construction for the Enhanced Shield Building circular wall, and other CA Modules. These included:

- the lack of an appropriate design code;
- the lack of a design methodology; and
- concerns whether the effects of transverse shear, in-plane shear and thermal loads on the modules had been adequately quantified.

These issues were sufficiently important for us to raise a Regulatory Issue in February 2010. Westinghouse responded to the three actions of the Regulatory Issue by providing additional information, including more detailed numerical analysis of structures benchmarked by laboratory testing. By June 2011 we were satisfied that, while there was still outstanding work to complete, the majority of the key actions had been addressed and we wrote to Westinghouse to close the Regulatory Issue. The remaining work has been identified as a GDA Issue.

From our assessment, we have concluded:

- The safety categorisation and classification of civil structures within scope were found to be acceptable.
- The final schedule of external hazards agreed for AP1000 reactor is considered acceptable.
- We are satisfied that the designs of the Enhanced Shield Building and Auxiliary Building are sufficiently robust to military and commercial aircraft impact.
- The load schedule and its application were found to be generally acceptable. However, this may be affected by the resolution of GDA Issues identified by the internal hazards assessment.
- The seismic design methodology used is only applicable to hard sites and is not applicable to soft and medium soil sites that may be appropriate for some sites in the UK. This would need further justification for each site chosen when the site-specific seismic spectrum is available. This will need to include the interaction between the nuclear island and adjacent structures.
- The finite element models used for the analyses were satisfactory.
- Westinghouse has made sufficient progress on the Enhanced Shield Building and CA Modules for us to close the Regulatory Issue and pursue remaining work as a GDA Issue.
- The basic structures of the Shield Building wall and CA Modules are likely to be more than adequate for the actual loads they need to resist. Although there is currently no recognised international standard for the design of these types of composite construction, we consider that Westinghouse are likely to be able to substantiate the design to our expectations, provided the further information within the GDA Issues is completed satisfactorily.
- The AP1000 reactor generic design is all based on imperial units. Westinghouse plans to provide construction information to suppliers for UK plants in metric, converted from the original imperial values. This is called "*quasi-metric*". Westinghouse's intent is that structural steel-rolled sections will be made in the UK using American sizes, and that imperial bolts and steel plates will be used for on-site construction. This relies on appropriate controls being employed, rather than designing-out the potential for on-site errors and so we believe that

this approach is not good practice. We are seeking further clarification and firmer specifications as part of a GDA Issue identified jointly with the Mechanical Engineering topic area.

- Westinghouse intends that all materials for civil structures (steel and concrete) used in the AP1000 reactor generic design are to US standards. In reality we expect that substitution of European for US materials may be proposed by suppliers, particularly bulk materials like concrete, and so any substitution will require robust control via Westinghouse procedures. Structural steel is an international commodity and there should not be much difficulty in sourcing material to US standards in the UK, although additional specification will be required on aspects such as ductility. Reinforcing bar is likely to remain to US standards since, if European reinforcing bars were to be substituted, this would have a major effect on the design. Further justification for Westinghouse's approach has been identified as a GDA Issue.
- Westinghouse uses a number of US Codes and Standards that have now been superseded. It has carried out a study of the differences between the superseded codes they have used and the current versions and has shown that the AP1000 reactor design codes are adequate. This study will need to be kept up to date as and when new codes are published.
- ONR expects spent fuel pools to have defence-in-depth against possible leaks through the structure. This means having multiple barriers to give redundancy. The AP1000 reactor has a primary liner with a leak detection system. Secondary containment is provided by the structure itself, but there is no independent means of leak detection. This has been identified as a GDA Issue.

There are four GDA Issues in this topic area related to:

- Further justification of the novel form of structure for the steel-concrete-steel composite walls and floors known as CA Modules.
- Further justification of novel form of structure for the steel-concrete-steel composite wall to the enhanced shield building.
- Materials – AP1000 reactor – civil engineering material standards and material specifications.
- Fuel handling area – secondary containment leak detection and leak collection system for Spent Fuel Pool.

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, our assessment included the following:

- Details of the PSA models and data, and the underlying supporting analyses.
- The methods, techniques and scope of the PSA.
- Conduct of an independent Risk Gap Analysis (RGA).

From our assessment, we have concluded:

- The AP1000 reactor PSA comprises Level 1 PSA, Level 2 PSA and a simplified Level 3 PSA. The scope includes consideration of internal initiated events and internal hazards and includes full power, low power and shutdown operating states. Westinghouse submitted a separate PSA for the Spent Fuel Pool. In general, the methods and data used in the PSA are well known, although not always up-to-date or aligned with the latest international good practices.
- The PSA is not a complete, or up-to-date, evaluation and is overly reliant on analysis done some time ago for the AP600 design without sufficient evidence of applicability to the AP1000 reactor.
- Our independent RGA concluded that risks of core damage and radioactive release for the AP1000 reactor are likely to be higher than Westinghouse estimates, but are lower than those figures for currently operating Pressurised Water Reactors (PWR).
- The AP1000 reactor PSA needs substantial improvements to meet modern standards; it does not allow a complete and reliable comparison against the numerical targets of our SAPs nor an effective ALARP evaluation. However, as the results of the RGA have suggested that the risks associated with this reactor appear to be low in comparison with currently operating reactors, it should be acceptable for construction in the UK.
- The results of the PSA and our RGA suggest that the risk to the public is low and potentially able to meet the Basic Safety Objectives (BSO) given in our SAPs (Reference 5).
- The AP1000 reactor PSA is not adequately supported by comprehensive, design-specific and fully traceable thermal hydraulic analyses that clearly identify the success criteria for the sequences. This has been identified as a GDA Issue.
- AP1000 reactor fire risk evaluation is not up-to-date or complete and there is therefore uncertainty in our understanding of the overall plant risk from fires for this reactor. A modern-standards fire PSA should therefore be developed and this has been identified as a GDA Issue.
- A number of findings were identified in all of the technical areas of the PSA and these will be carried forward as normal regulatory business. Also, a number of potentially important risk gaps will depend on matters beyond the generic design. So, a site-specific PSA will be required for each site, including a complete and updated Level 1, 2 and 3 PSA (Fuel Pool, Reactor at Power, Low Power and Shutdown, Internal Events and Internal and External Hazards). This should be accompanied by an ALARP evaluation and a demonstration that no further improvements to reduce the risk are reasonably practicable. This will be progressed in the site-specific phase of any future AP1000 reactor construction project.

There are two GDA Issues in this topic area related to provision of:

- PSA success criteria that are supported by AP1000 reactor specific thermal-hydraulic analysis of sufficient detail and scope and fully traceable.
- An AP1000 reactor specific Fire PSA to justify the plant risk from fires.

Fault Studies, Transient Analysis and Severe Accidents

Fault Studies

The transient 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 that 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.

For GDA, our assessment included the following:

- The design basis analyses performed in support of the AP1000 reactor, sub-divided into:
  - faults where the integrity of the primary circuit is maintained (such as loss of feed faults, loss of flow faults, and reactivity faults);
  - faults where a break occurs somewhere on the primary circuit (Loss of Coolant Accidents (LOCA));
  - faults occurring during shutdown conditions; or
  - faults occurring away from the reactor in the spent fuel pond.
- The validation of the computer codes which are used to model design basis faults, including independent confirmatory analysis undertaken by our technical support contractors using alternative computer codes and independent analysts.

It is has been agreed with Westinghouse that it is more appropriate to assess operational matters such as load-following, the proposed Technical Specifications, the emergency operating procedures and the site-specific radiological consequence assessments during the site-specific phase. Hence these items are considered as being outside the scope of the GDA, although certain generic aspects, such as the limits and conditions for safe operation, or operator actions required to respond to faults, are covered within GDA.

From our assessment, we have concluded:

- Westinghouse has improved the design basis safety case for the AP1000 reactor through the additional analysis performed in response to our regulatory challenges.
- Westinghouse has been able to extend the design basis to demonstrate that the design is tolerant to passive single failures at the functional level. They have also extended the design

basis to cover complex situations in which a combination of events may occur, although this is an area where there is further work still to be done. This has been identified within a number of GDA Issues, including that on the Fault Schedule.

- Westinghouse has proposed a number of important design changes to the reactor protection system on the AP1000 reactor that will significantly improve the safety of the design. The design changes include:
  - an upgrading of a number of active systems to Class 2 safety standards, including: the start-up feedwater system, the component cooling water system, the service water system, and the diesel generators. For example, the two train separation of the normal residual heat removal system has been increased, while the diverse actuation system has been upgraded from a 1-out-of-2 system to dual 1-out-of-2 system with elements of the architecture 2-out-of-3;
  - modification to improve protection against a Steam Generator Tube Rupture (SGTR) fault;
  - implementation of additional reactor trip signals;
  - modification to reduce the risk of spurious operation of valves leading to depressurisation of the primary circuit; and
  - improvements in the design of the SFP.

There are eight GDA Issues in this topic area related to:

- Demonstration of alignment of all design basis faults and related core design limits with the agreed GDA design reference.
- The safety case for the SFP incorporating the identified design changes.
- Further analysis to ensure adequate provision of functional diversity for frequent faults.
- The reasonable practicability of providing additional alarms and protection based upon in-core instrumentation.
- Potential enhancements to the diverse safety injection system.
- Evidence that the In-containment Re-fuelling Water Storage Tank (IRWST) is functionally capable of cooling the Passive Residual Heat Removal (PRHR) system during intact circuit faults for 72 hours.
- Improvements to the submitted safety case for shutdown faults.
- The acceptability of the AP1000 reactor Fault Schedule (a summary of the design basis safety case in tabular form).

Containment and Severe Accidents

Included within the Fault Studies area is the topic of severe accident mitigation. Here ONR is looking at safety arguments for challenges to the containment from high pressure or temperature in accident conditions and design features that are provided to cope with such challenges as a molten core. For the AP1000 reactor one of the key features of the safety case is the claimed ability of the reactor pressure vessel to retain and cool the molten core. The main lines of our investigation have been the examination of the key uncertainties with the modelling of these complex phenomena and how they are validated, and, the capability of the combustible gas management system to maintain the containment hydrogen concentration within acceptable limits.

For GDA, our assessment included the following:

- Thermal-hydraulics challenges to the containment during design basis accident conditions.
- Operation of the PCS during normal operation and fault conditions.
- Strategy for severe accident progression management.
- Key features of the design to mitigate against the consequence of a severe accident, such as In-vessel Retention (IVR) of the molten material and long-term cooling of debris within the RPV lower head.
- Independent confirmatory analysis to examine the claims for the maximum pressures and temperatures within the containment environment during accident progression.
- Challenges to the containment hydrogen control and management system and the ability to maintain the containment hydrogen concentration within acceptable limits.
- Aspects of validation of the computer codes employed to support the claims within the safety submissions.

From our assessment, we have concluded:

- During the Step 4 assessment, Westinghouse has provided additional information and supporting analysis to improve its safety case in response to our regulatory challenges.
- Considering the large uncertainties associated with conditions likely to exist during these accident conditions, an acceptable safety case has been made for the design features of the AP1000 reactor.
- An adequate safety case has been provided to show that the containment design can withstand the various thermal hydraulics challenges in design basis accident conditions.
- The AP1000 reactor is designed to prevent the failure of RPV lower head, and hence retain the resulting molten material within this volume. This concept is referred to as in vessel retention (IVR) and is achieved by cooling the RPV through the introduction of cooling water into the reactor cavity cooling annulus from the IRWST. Although there are large uncertainties in this complex analysis we are satisfied from our confirmatory analyses that, for the predicted decay heat levels, IVR appears to be successful. We would expect further bounding analysis to be performed at the site-specific stage to provide further confidence in the IVR concept, as the detail of the design progresses.
- The hydrogen management system is judged to be acceptable, subject to the successful completion of the residual aspects relating to the adequacy of the power supply to the hydrogen igniters.
- Our assessment has largely supported the claims made for the effectiveness of the PCS during normal operations, and performance of the water cooling of the containment during accident conditions. Remaining uncertainties in this area are:

- condensate formation, collection and return to the IRWST during accidents. This has been identified as a GDA Issue raised under the Fault Studies topic area; and
- fission products release-rate and timing into the containment has been identified as a GDA Issue. This is reported under the Reactor Chemistry topic area.

- International research is continuing to further improve the understanding of the phenomena of core melt progression and molten core concrete interaction. We note that Westinghouse has been active in support of these areas and intends to maintain its involvement.

There are no GDA Issues in this topic area.

Control and Instrumentation

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. ONR's assessment in this topic area includes reviews of both hardware and software aspects of these systems.

In the UK this topic is commonly referred to as Control and Instrumentation (C&I), although in the US the order is reversed and I&C is used, but we will refer to the former throughout this report.

For GDA our assessment 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. This included:

- Arguments and evidence presented in the safety case.
- Principal design and implementation standards for all C&I safety and safety-related systems (i.e. the systems important to safety (SIS)).
- Westinghouse's safety case for selected key C&I Systems Important to Safety (SIS) and platforms used to implement the systems (e.g. covering the Safety Class 1 Protection and Safety Monitoring System (PMS) and the Safety Class 2 Diverse Actuation System (DAS)).
- C&I architecture, including provision for defence-in-depth, independence and diversity.
- Diversity of those systems contributing to implementation of the highest category safety functions (i.e. the PMS and DAS).

From our assessment, we have concluded:

- The PCSR and supporting documentation cover the main C&I SIS expected in a modern nuclear reactor.
- Based on review of the standards implemented by Westinghouse for the selected key C&I SIS and Westinghouse's standards conformance submission, the C&I standards are broadly in accordance with those expected in the nuclear sector.
- Westinghouse's safety cases for the PMS and DAS are in general accordance with our expectations (noting that further implementation detail needs to be added to the safety cases following design completion).
- The overall C&I architecture is generally in accordance with expectations.

There are ten GDA Issues in this topic area grouped into eight themes, as follows*:*

- Lack of design and safety case information for the DAS, including for the operating and maintenance philosophy, and substantiation for the significant changes made to the DAS architecture (i.e. from two-out-of-two actuation voting to two-out-of-three / one-out-of-two twice) to significantly improve fault tolerance and availability during plant operation.
- Change of DAS technology from being based on complex Field Programmable Gate Arrays (FPGA) to conventional electronics in order to address a major concern on DAS and PMS / Component Interface Module (CIM) diversity. ONR has agreed to the principle of using conventional electronics and this GDA Issue covers the implementation of the more detailed design of this important system.
- Additional demonstration of diversity between the primary and diverse protection systems (PMS / DAS and Plant Control System (PLS) / DAS) which needs to be undertaken as a consequence of the DAS technology change.
- Provision of equipment to reduce the frequency of spurious Automatic Depressurisation System (ADS) operation to lead to reactor depressurisation.
- Fully defining the approach to the justification of SMART devices (based on computer technology).
- Enhancements to the safety cases for the PMS, Safety Class 1 CIM and the DAS.
- Provision of improved safety cases for the safety-related Class 2 / 3 Distributed Control and Information System (DCIS) and the Ovation platform.
- Provision of Safety Class 1 displays and controls outside of the Main Control Room (i.e. in a Remote Shutdown Station).

Electrical Engineering

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. For some electrical equipment, the safety functions and the specification of technical requirements were examined in GDA, but the evidence of fulfilment of those functions and requirements can only be demonstrated when the detail design of the equipment is completed and it has been tested, during the site specific phase.

For GDA, our assessment included the following:

- Review of power system protection in the generic UK AP1000 reactor design.
- Review of the principles and methodologies that show the resilience of the electrical distribution network to the effects of fast transient disturbances.
- Study of three-phase and single-phase short-circuits on the system.
- Study of the effects of transient disturbances on the electrical system during motor starting and power system fault conditions.

- Review of the Direct Current (DC) and uninterruptible Alternating Current (AC) systems.
- Review of power quality on the distribution system.
- Review of maintenance philosophy and condition monitoring.
- Review of earthing and lightning protection.
- Review of the codes and standards to be used for a UK AP1000 reactor.
- Protection against voltage transients.
- Review of the electrical system design against ONR SAPs.
- Impact of grid disturbances.

From our assessment, we have concluded:

- The fundamental design of the electrical system is based on sound principles. However, this will need to be substantiated by the presentation of claims, arguments and evidence for the electrical system architecture in the safety case. This substantiation should also demonstrate that essential maintenance activities will not threaten continuity of supply. The substantiation by the presentation of claims arguments and evidence has been identified as a GDA Issue.
- Independent assessments of the Westinghouse design by modelling extremes of transient operating conditions has confirmed the resilience of the design of the electrical network to system disturbances due to such events as short circuits and overvoltage transients.
- The structure of the electrical system provides sufficient capacity to meet load requirements in all operating modes of grid supply, diesel supply and battery supply when all parts of the electrical system are available and in operation.
- The principles proposed in the protection philosophy provide a good basis for protecting the electrical system to minimise the effects of electrical faults.
- The Class 1 and Class 2 battery-powered systems are designed in a well-structured manner according to defined and documented processes. Adequate margins are applied and battery rating is based on worst condition of operating temperature and ageing.
- Westinghouse has presented comprehensive proposals to apply International Electrotechnical Commission (IEC) Standards to the design of the AP1000 reactor electrical system as part of implementing the adaptation of the design from an operating frequency of 60Hz to 50Hz.
- The assessment has been carried out on the principles on which the AP1000 reactor design is based, including performance specifications, but the detailed design will be carried out at the site-specific stage and this has limited the extent of our assessment. As a result we will need to assess the detailed design when it is available. This will be progressed during the site-specific phase. This will need to include: incorporation of studies of fast transients and Automatic Voltage Regulator (AVR) failure; performing harmonic assessment during detail design; incorporation of IEC Standard 50Hz equipment; and adoption of UK Safety Classifications in the design of the plant electrical distribution system.

There is one GDA Issue in this topic area related to:

- The presentation of claims, arguments and evidence for the electrical system architecture in the safety case.

Fuel Design

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

For GDA, our assessment included the following:

- Aspects of the fuel and core design that could conceivably lead to impairment of fuel cooling.
- Design criteria which during Step 3 appeared not to meet UK safety objectives or modern standards.
- Areas of the design that introduce novel features.
- Validation of key computer models.

The use of mixed oxide fuel, or reprocessed fuel, is out of scope for GDA.

From our assessment, we have concluded:

- The fuel design for AP1000 reactor is a development of existing Westinghouse products and appears to have benefited from a successful programme to improve the performance and reliability of the fuel.
- Westinghouse has provided a wide-ranging safety analysis in the Fuel Design topic area.
- Additional information Westinghouse provided to us during GDA has shown that the approach to qualifying new aspects of the design appears to be systematic and reasonable.
- Westinghouse has enhanced core diagnostic capabilities by addition of in-core instrumentation. However, some aspects of its use require further justification.
- Westinghouse is continuing to make progress in its analysis methods and in minimising the potential for degradation of the fuel condition during use.
- As a result of the GDA process, measures have been taken to improve the protection of the fuel cladding against cracking during faults. Moreover, additional safety constraints and improved analysis techniques have been developed.
- More detailed analysis of fuel damage has shown that, even with the temperatures experienced in the worst credible loss-of-coolant accident, a coolable geometry is likely.
- An acceptable generic case has been made for loading Westinghouse fuel into the AP1000 reactor. A number of core loading pattern strategies have been considered, but a selection will need to be made by the licensee during the site-specific phase and this will need to be analysed and justified.

- Research and development including fuel examination and testing is ongoing and should provide additional data to underwrite the justification for assembly distortion, CRUD,[†] and the dry storage of spent fuel. This will need to be reviewed during the site-specific phase.

There are three GDA Issues in this topic area relating to:

- Safety justification for modelling of fuel pin performance, with particular reference to the modelling of fuel pellet temperatures.
- Forces on reactor internals in the event of a large depressurisation fault.
- The effect of any potential malfunction of the BEACON™ core monitoring computer code.

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.

For GDA, our assessment included the following:

- The justification, implications and control of primary coolant chemistry during all modes of operation. This included consideration of nuclear reactivity control using boron, the effects of coolant chemistry on the integrity of pressure boundaries, protection of fuel and core components and production, transport and deposition of radioactivity, including its influence on radiological doses to workers and ultimately to wastes.
- Features of the design, material choices or chemistry controls which reduce radioactivity to ALARP.
- The main secondary circuit systems which control or are influenced by chemistry.
- Engineered systems which allow the operator to control, monitor or change the plant chemistry.
- Storage of nuclear fuel within ponds, including the effects of pond chemistry.
- Systems which mitigate the release of radioactivity to the environment in either the liquid or gaseous form.
- Design basis and beyond design basis accidents, including the production, release and control of hydrogen and fission product nuclides.
- Arrangements for moving the safety case to an operating regime, including the derivation of suitable limits and conditions and the arrangements for specifying plant chemistry.

[†] Crystalline material (usually oxides) deposited on a heat transfer surface, increasing its roughness and, in some cases, introducing a resistance to heat transfer.

From our assessment, we have concluded:

- Westinghouse does not specify the operational chemistry regimes or limits and conditions related to chemistry for the AP1000 reactor, referring instead to industry guidance. As such Westinghouse is not able to make ALARP claims for the plant chemistry in these areas and this will be required as the safety case for a UK AP1000 reactor develops. The lack of limits and conditions has been identified as a cross-cutting GDA Issue.
- The AP1000 reactor uses natural boric acid, without the capability to recycle the effluent. This simplifies the boron management of the plant, removes many components and simplifies concerns regarding accumulation of radioactivity and contamination. The case presented for managing boron in the primary circuit, including the potential for inadvertent dilution, appears reasonable.
- Westinghouse has provided assurance that the cobalt content of alloys (a significant radiation source) in the AP1000 reactor has been reduced significantly. Cobalt reduction should be kept under review during the site-specific phase as equipment suppliers may vary from site to site. Our independent calculations show that the AP1000 reactor may produce more of the cobalt isotopes than PWRs with similar power outputs. This means that the AP1000 reactor may need additional controls to assure that this source of radioactivity has been reduced to ALARP.
- Westinghouse proposes addition of zinc to primary coolant to help control radiation fields. It was less clear what the effect of zinc on fuel CRUD would be, but Westinghouse provided additional evidence from which we conclude that waste generation will be no worse with zinc and radiation should be lower.
- The major chemistry systems that allow the operator to control and change the primary chemistry, including those that are used during accidents, have been simplified and made passive, in line with the overall plant design philosophy, but are functionally very similar to existing PWRs.
- The Chemical and Volume Control System (CVS) is novel in a number of aspects as it operates at full reactor pressure, inside containment and with direct injection of hydrogen for corrosion control. However, the hydrogen dosing arrangement was subject to a late design change during GDA and we require additional evidence to demonstrate that this system will operate as expected. This has been identified as a GDA Issue.
- The primary coolant sampling system has been simplified in the AP1000 reactor design. Westinghouse incorporated a design change late in GDA that significantly improves the design, however we still have some questions regarding sampling adequacy and waste generation. This has been identified as a GDA Issue.
- Westinghouse has produced a chemistry manual specific to the AP1000 reactor to help support a licensee to build up expertise in such areas as control of chemicals used in fabrication, commissioning, plant monitoring and maintenance.
- A novel design choice for the AP1000 reactor secondary circuit is the use of electrodeionisation (EDI) for purification of the steam generator blowdown. All other PWRs, with the exception of one, use conventional ion exchange-based treatment systems. An adequate case has been made for this system for GDA, although we will encourage further testing under actual plant conditions.

- The AP1000 reactor features passive autocatalytic recombiners (PAR) to control and remove combustible gases released into the containment during design basis events, and igniters for severe accidents. From a chemistry perspective the claims, arguments and evidence in this area are reasonable.
- The containment of the AP1000 reactor has been designed to retain radioactive material in an accident which simplifies the management of radioiodine. The AP1000 reactor does not include a re-circulating, pH buffered spray system for fission product control as in many PWRs, instead relying on passive deposition mechanisms driven by external cooling supplemented by a spray if necessary. The chemistry aspects of this case were presented to ONR late in GDA and the assessment has not been completed in this important area, including justification for the scale and timing of releases into containment. This has been identified as a GDA Issue.
- In the unlikely event that the core becomes hot enough to melt fuel, the AP1000 reactor provides an in-vessel melt retention system. This involves flooding the reactor vessel pit with water. The Westinghouse analysis of IVR appears conservative and we are satisfied that a reasonable argument has been presented.
- As a result of the GDA assessments, the generic PCSR for the AP1000 reactor has been updated to include a chapter dedicated to Reactor Chemistry. This is a valuable addition to the safety case.

There are three GDA Issues in this topic area related to:

- Further evidence that the source term for severe accident release has been appropriately applied for the AP1000 reactor design, including fractions and timing of release in both the short and long term.
- Further evidence to support the design of the primary circuit hydrogen injection system.
- Further justification, potentially including further design changes, will be needed for the primary circuit sampling systems to meet UK expectations.

Radiological Protection

This topic includes the assessment of measures intended to restrict exposure of workers and the public to radiation so far as is reasonably practicable, including the adequacy of engineering control (such as radiation shielding) measures to control radioactive contamination, and criticality safety.

For GDA our assessment included:

- External radiation hazards associated with direct radiation from structures, systems and components.
- Internal radiation hazards resulting from the generation of surface and airborne contamination.
- Features of the design which are intended to reduce the exposure of workers and the public under normal conditions.

Our assessment focussed on the following key areas:

- Radiation sources.
- Designated areas (radiological classification of areas / radiological zoning).
- Shielding.
- Contaminated areas.
- Ventilation.
- Radiological instrumentation.
- Decontamination.
- Optimisation for work activities (including fuel route).
- Waste handling and decommissioning.
- Public exposure from “direct shine” (direct radiation originating from within the site boundary).
- Possible doses from accident conditions.
- Criticality safety for fuel stored outside the reactor core (e.g. in spent fuel ponds).

A number of items have been agreed with Westinghouse as being outside the scope of the GDA process as they are heavily reliant on operational factors, and hence these have not been included in our assessment. An example is the assessment of doses associated with mid-loop working, which will be assessed at the site specific phase should the licensee wish to undertake this practice.

From our assessment, we have concluded:

- The plant and its operations have been designed to ensure that engineered features would restrict exposures to workers to ionising radiation so far as is reasonably practicable during normal operation.
- Westinghouse has demonstrated that it has made systematic improvements to the radiological protection aspects of the design throughout the design process, including the adequate development of shielding structures which have been adapted to the specific radiological conditions associated with an AP1000 reactor.
- The AP1000 reactor generic safety case has been informed by a thorough and robust analysis of the threats posed by radiological hazards.
- Predicted doses to members of the public are very low.
- We do not accept that the provisions for criticality control in the spent fuel pool meet international good practice. Westinghouse has presented criticality control arguments based on the presence of soluble boron in the pool and on fuel burn up. We believe that adequate control should be achieved through the use of suitable physical spacing between fuel assemblies, combined with fixed poisons. Westinghouse has made suggestions for how this can be addressed and this matter has been identified as a GDA Issue.
- We believe that insufficient space is available in the AP1000 reactor health physics facilities, including changing rooms, radioactive laboratories etc. Westinghouse has indicated that it intends to address any space constraints within the main nuclear island buildings by

providing additional facilities on each site, external to the nuclear island. This will therefore be progressed during the site-specific phase.

There is one GDA Issue in this topic area related to:

- The criticality safety case for the spent fuel pool.

Mechanical Engineering

This typically includes the safety assessment of 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 routeing of the mechanical equipment and systems to ensure appropriate maintenance regimes can be developed, and that equipment is protected from hazards and degradation.

Much of Westinghouse's GDA submission has been restricted to high level specifications as the detailed equipment designs will be defined as part of procurement, and this has limited the extent of our assessment. Nevertheless, for GDA our assessment included:

- Assessment of the safety functions of reactivity control, heat transfer and removal, and containment of radioactive substances associated with mechanical equipment and systems.
- Review of a wide range of mechanical items and systems important to safety, including cranes used for nuclear lifting, nuclear ventilation systems, pumps and valves, heat exchangers and associated heat transport systems, Control Rod Drive Mechanisms (CRDM), and mechanical handling systems.
- Assessment of the scope and extent of claims, arguments and evidence presented.
- A review of the level of design completeness.
- Assessment of safety categorisation and classification, design and reliability claims and equipment qualification.
- Consideration of the layout, access, ingress and egress provisions to facilitate operation, inspection, testing, maintenance and equipment replacement.
- The design process applied by Westinghouse in certain areas.
- Metrication of the AP1000 reactor.
- A "deep slice" assessment of the squib valve designs used as part of the Passive Core Cooling System.

From our assessment, we have concluded:

- Generally the equipment proposed for the AP1000 reactor has a good mechanical engineering pedigree, well supported by operational experience feedback.
- Information from factory acceptance tests and site acceptance tests, which in general form an important suite of evidential information, are not generally available within GDA since in many cases suppliers have not yet been selected.

- In response to our challenges, Westinghouse has aligned the classification of duty systems with important safety functions with UK practice. This is part of the graded approach to safety, to ensure that design, procurement, operational and maintenance attention is focused proportionately on equipment with higher safety importance.
- Westinghouse has also agreed to make some important changes to the nuclear ventilation system as a result of interactions within GDA. This includes raising the height of the nuclear ventilation discharge stack in line with UK expectations, and also the provision of passive High Efficiency Particulate Air (HEPA) filtration to additional areas of the plant.
- We have not accepted as adequate the engineering substantiation for the Mechanical Engineering (including pyrotechnic) aspects of the squib valve designs. The squib valves are fast acting valves that are important to safety and are used as part of the Passive Core Cooling System within the AP1000 reactor. These are novel designs whose development has continued during GDA. Although the design development and associated prototype testing have made some good progress, we are not yet satisfied that the safety justification and substantiation (including documentation) is adequate given the importance of these valves. This has been identified as a GDA Issue.
- Although the AP1000 reactor was originally conceived in imperial units, it is the UK Regulator's expectation that an AP1000 reactor built in the UK will be metric. Progress has been made in this area during GDA, however further work is still required and a number of exceptions proposed by Westinghouse, such as widespread use of imperial fastenings, are either not acceptable, or require further definition and justification. This has been identified as a GDA Issue.
- Space is limited within the AP1000 reactor and the design has minimised pipes and valves to reduce cost and maintenance. However, one result is that there are limited features to enable the safe isolation and drainage of pipework for testing and maintenance. For example Westinghouse has proposed the use of pipe freezing as a routine activity, and further design work and justification is required in this general area. This has been identified as a GDA Issue.

There are three GDA Issues in this topic area related to:

- Squib Valve concept and design substantiation.
- Metrication of the AP1000 reactor to meet UK expectations.
- Provision of adequate design features to enable safe isolation and drainage of pipework for testing and maintenance activities.

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, our assessment included the following:

- Categorisation and classification of systems, structures and components (SSC).
- 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).
- Lifetime ageing of materials (including neutron irradiation embrittlement).
- In-service inspection to the extent of ensuring that there is adequate access, but noting that detailed in-service inspection proposals have been agreed as being outside the scope of GDA.
- A particular focus on pressure boundary components where it is necessary to show that the likelihood of gross failure is so low that it can be discounted. Westinghouse has designated these pressure boundary components as the Highest Safety Significance (HSS) components, with a further designation of High Integrity (HI) where a similar demonstration is also required.

From our assessment, we have concluded:

- Westinghouse has designed the AP1000 reactor nuclear pressure vessels and piping against the American nuclear design code, ASME III, and we judge this to be generally acceptable for nuclear pressure systems.
- There are a small number of critical components where it is necessary to show that the likelihood of gross failure is so low that it can be discounted. We do not accept that the normal code requirements are sufficient to provide this level of confidence. Westinghouse has accepted the need in the UK to make a higher level demonstration of structural integrity integrating fracture mechanics analyses, material toughness and qualification of manufacturing inspections that go beyond ASME code requirements.
- We have independently verified the adequacy of a small number of the Westinghouse fracture mechanics calculations and, while a number of apparent discrepancies were identified, we are generally satisfied with the approach that has been taken. Further detailed assessment of some of the fracture mechanics calculations is still required and this has been identified as a GDA Issue.
- We have undertaken a full review of some of the Westinghouse manufacturing inspection proposals and a high-level review of the others. Overall we conclude that it should be possible for Westinghouse to provide a suitable demonstration for the safety case, however a more detailed assessment will be required to confirm this, and this has been identified as a GDA Issue.
- Our independent review of code compliance against ASME III on a number of the main vessels identified a number of apparent discrepancies. Westinghouse has provided additional supporting evidence to demonstrate code compliance and this gives confidence that the vessels are satisfactory. However, full resolution of the apparent discrepancies is required and this has been identified as a GDA Issue.

- The principle of using of cast stainless steel for the reactor coolant pump bowl construction had been justified. However, Westinghouse introduced a design change for the reactor coolant pumps at the end of GDA Step 3. This included a late change to the material used for the pump casing, which is an important part of the reactor pressure boundary. Technical reports on the casing design arrived late in Step 4. We have sufficient knowledge to be satisfied that the design and material choice are likely to be adequate, however a more detailed assessment is required and this has been identified as a GDA Issue. In addition, a further consequence assessment will be required to support the classification of the pump casing as a non-HSS component or, alternatively, the pump casing will have to be re-classified and justified as HSS. This has also been identified as a GDA Issue.
- Westinghouse has not yet completed demonstration of a 60-year fatigue life for the pressuriser surge line against the ASME III code. The work is ongoing and this has been identified as a GDA Issue.
- We are generally content with the analysis work that has been undertaken for the containment vessel, but there is ongoing work to demonstrate integrity against a thermal load case. In addition the containment vessel welds in accordance with ASME code requirements are not post-weld heat treated. Westinghouse has not, so far, completed the justification that the vessel is sufficiently tolerant of welding defects given the high residual stress and this has been identified as a GDA Issue.
- In addition to meeting the requirements of the ASME III code, we believe that additional controls on material composition and manufacturing processes are reasonably practicable for the RPV, steam generators and pressuriser. It will be the responsibility of the future licensee to specify and agree procedures at a detailed level with suppliers of the main forgings and this will therefore be progressed during the site-specific phase.
- We have not yet fully concluded on the adequacy of the justification for using non-nuclear codes for Class 2 pressure equipment and additional evidence is required to justify why the accumulator tanks in the passive core cooling system can be designed and constructed to ASME III Class 3, which is a lower class than in previous designs. These matters, which arose late in the GDA assessment, still need to be resolved and have been identified as GDA Issues on categorisation and classification.
- Westinghouse has 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.

There are six GDA Issues in this topic area related to:

- The safety case for avoidance of fracture on high integrity vessels.
- The fatigue analysis for the pressuriser surge line.
- The justification for the material and design of the reactor coolant pump casing.
- Additional analysis for the containment vessel.
- Compliance of the AP1000 reactor main structural components with ASME III design rules.
- The categorisation and classification of the structural components.

Human Factors

Human Factors is the study of human physical and psychological capabilities and limitations, and the application of that knowledge to the design of work systems. Within the nuclear context, Human Factors is concerned with the human contribution to nuclear safety during facility design, construction, commissioning, operation, maintenance and decommissioning. ONR requires that a systematic analytical approach be applied to understanding the factors that affect human performance and reliability.

For GDA, our assessment included the following:

- Substantiation of human-based safety actions – ensuring that the risks from human actions have been reduced to ALARP. This included providing judgement on the completeness of the human based safety claims, and the adequacy of the justification or process to ensure that claims are reasonable and will be achieved by the design.
- Generic Human Reliability Assessment (HRA); particularly relating to the HRA methods and application.
- Engineering systems' maintenance reliability from a Human Factors perspective.
- Human Factors Integration (HFI) into the design and safety case of the AP1000 reactor.
- Plant-wide generic Human Factors assessment to provide a judgement on the adequacy of the overall plant design from a Human Factors perspective.

The following items have been agreed with Westinghouse as being outside the scope of GDA:

- Detailed procedure design.
- Final human machine / computer interface designs.
- Work organisation.
- Staffing levels.
- Administrative controls.

From our assessment, we have concluded:

- Overall, Westinghouse has undertaken a significant volume of quality Human Factors assessment work to support their GDA submission and it has applied considerable competent resource to improve its position on Human Factors from that at the end of GDA Step 3.
- There are gaps in the Human Factors safety case, some of which are significant and have resulted in a GDA Issue. Westinghouse has delivered additional analyses to address these concerns, however these were delivered late in Step 4 and have not yet been fully assessed.
- In general, we conclude that Westinghouse has improved its human factors substantiation, and has identified some sources of operator failure that were omitted by the PRA. Westinghouse has captured and incorporated some valuable Utility input, together with some potentially useful error reduction strategies, and some of the human based safety claims seem reasonable.

- Some areas of the safety case will require further work, to be addressed as routine regulatory business during the site-specific stage.
- The qualitative Human Factors assessment work undertaken by Westinghouse to develop the Human Factors safety case for the AP1000 reactor has not been reflected in the HRA, and it is our judgement that the HRA should be fully revised. We have questioned the general applicability of the Technique for Human Error Rate Prediction (THERP), and we do not consider that the current model represents recognised good practice in terms of quantitative HRA. This is mostly a result of the age of the model, its incompleteness, and a number of detailed modelling issues.
- In general, we conclude that Westinghouse has made a good start to address the human reliability aspects of maintenance and that there is evidence of analysis and design input to support its claims in this area. However, there are significant gaps and these will be taken forward as part of the GDA Issue.
- Westinghouse has a limited Human Factors Engineering (HFE) programme of work but there is little evidence of a fully integrated programme that actively works with other related technical disciplines in a cohesive manner to optimise the design and develop and iterate the safety analysis. In addition, although the major components of a recognisable Human Factors Integration programme exist, there are significant omissions.
- We consider that in general the quality of the design based Human Factors aspects across the wide range of areas assessed is adequate, and therefore likely to support claimed human reliabilities.

There is one GDA Issue in this topic area related to:

- Completeness of the Human Factors safety case.

Management of Safety and Quality Assurance

The topic of Management of Safety and Quality Assurance (MSQA) addresses the Westinghouse Quality Assurance (QA) and Management of Safety (MOS) organisational and procedural arrangements to deliver the AP1000 reactor GDA submissions. Where possible, ONR and the Environment Agency have worked together in our dealings with Westinghouse in this topic area.

For GDA, our assessment included the following:

- Management system, including audit and assessment, non-conformance and records management.
- Training and competency of personnel.
- Audit and assessment, including non-conformance reporting.
- QA arrangements for control of design development.
- QA arrangements for software control supporting design development.
- QA arrangements for control of design changes.
- QA arrangements supporting the procurement of GDA services.

- Configuration control of GDA submission documentation, i.e. the Safety Case, Design Reference and the GDA Master Submission List.

A number of items were identified as out of scope, for example the QA arrangements for all manufacturing activities. These will be addressed during the site-specific phase.

From our assessment, we have concluded:

- The management system for the GDA project, and its application, has developed considerably during Step 4.
- Westinghouse has applied robust monitoring and assessment processes to the project; this has included adequate arrangements for non-conformance management.
- A number of design changes were made during Step 4 which we were not formally notified of, and the safety documentation that the assessors were working on has been changing. Westinghouse subsequently requested their inclusion in GDA, but the result was that the GDA DR does not fully align with the safety documentation. ONR and the Environment Agency have jointly identified the control, maintenance and development of the GDA submission documentation as a GDA Issue in the cross-cutting topic area.
- Westinghouse has experienced and knowledgeable staff and a commitment to retain adequate technical resources
- Westinghouse operates well-established arrangements for the selection and surveillance of suppliers as part of its procurement activities. Some weaknesses were identified associated with the application of these arrangements to the procurement of GDA services, but these were satisfactorily addressed during Step 4.
- The QA arrangements supporting the development of the design are adequate, for example design verification, software control, design review, and design change. However, the application of some of these processes to the UK project has been limited, for instance the design reviews conducted to date have not included UK requirements and the design change process has not considered the impact to the UK safety submission fully.

There is one GDA Issue in this topic area which concerns the control of the GDA submission documentation, and this is reported under the cross-cutting topic area.

Radioactive Waste and Spent Fuel Management

Under this topic, we have examined the proposals for the safe minimisation, handling, storage and disposal of radioactive waste arising from all parts of the power station, and we have reviewed the proposals for decommissioning. Where possible, ONR and the Environment Agency have worked together in our dealings with Westinghouse in this topic area.

The radioactive waste facilities that are not on the nuclear island will be developed during the site-specific phase. So, for GDA, we asked to see sufficient information to give us confidence that these facilities can be developed and the spent fuel and waste can be safely stored and then retrieved, transported and, finally, disposed of.

For GDA, our assessment included the following:

- Whether the wastes that an AP1000 reactor will produce have been identified in sufficient detail.
- The suitability of the plans put forward for short-term storage, and conditioning of the wastes for long-term storage and eventual disposal.
- The suitability of the plans for long-term storage of Intermediate Level Waste (ILW) and spent fuel to show that this is safe and that the waste will be in a condition that would allow it to be transported for disposal.
- Whether the wastes that an AP1000 reactor will produce are suitable for disposal.
- The outline plans for decommissioning an AP1000 reactor.
- The suitability of proposals for knowledge management over the lifetime of the facilities.
- The ability of Westinghouse to produce the radioactive waste management safety case for the AP1000 reactor, showing the through-life safety proposals.
- The Westinghouse plan for the development of waste management facilities to show that these can be developed in a timely manner.

From our assessment, we have concluded:

- Westinghouse has identified the typical wastes that an AP1000 reactor will produce.
- The size of the waste treatment facilities proposed in the generic AP1000 reactor design is too small to provide safe and environmentally acceptable short-term storage options and subsequent conditioning for the wastes that an AP1000 reactor is foreseen to produce. Westinghouse has addressed this by advising that new facilities, off the nuclear island, will be developed during the site-specific phase.
- The wastes can be conditioned and there is no reason to believe that the resulting products are not suitable for long-term storage and eventual disposal.
- The plans for long-term storage of ILW are similar to those used elsewhere in the UK nuclear industry.
- The design of the spent fuel storage facilities on the nuclear island should allow a licensee to address the needs of the long-term storage requirements so that spent fuel remains in a condition that would allow it to be transported for disposal. However, the size of the at-reactor spent fuel pool may restrict the licensee’s flexibility and this will need to be addressed during the site-specific phase. The licensee will also need to continue to consider potential degradation mechanisms and periodically inspect the stored fuel to maintain confidence that it remains in a suitable condition.
- The plans for decommissioning an AP1000 reactor are to a suitable level to show that this can be achieved in a safe and environmentally acceptable way and that the wastes produced are suitable for disposal.
- The Radioactive Waste Management Case Mapping Document for the AP1000 reactor shows that the through-life Westinghouse proposals are in sufficient detail to be confident that there are no foreseeable reasons why the waste cannot be managed safely.

There are no GDA Issues in this topic area.

Cross-cutting Topics

Certain safety and environmental aspects cut across a number of different technical topic areas and so these have been managed in a cross-topic manner. These are discussed in this section.

Most of these “cross-cutting” aspects have been addressed within the topic area where the bulk of the work lies – i.e. the “lead” topic area. Examples are:

- Severe accidents.
- Boron dilution.
- SMART instruments (computer-based devices)
- Dropped loads.
- Radioactive source terms.

The assessment of these aspects is reported in the summary sections above, and within the detailed assessment reports.

However, for some cross-cutting aspects there was wider cross-topic working and these are reported below. These topics are:

- Control of the PCSR and MSL against the Design Reference.
- Design changes.
- Arrangements to identify the limits and conditions necessary in the interests of safety.
- Metrication of the AP1000 reactor.
- Safety function (SF) categorisation and SSC safety classification.
- Spent Fuel Pond.

From our assessment, we have concluded:

- We accepted the DR in October 2010 subject to some clarifications. At that time Westinghouse set the DRP at 16 September 2010. Westinghouse has an ongoing workstream to incorporate the subsequent design changes that we have agreed can be included in GDA.
- The PCSR for the AP1000 reactor, issued in December 2009, was found to have significant shortfalls in terms of content and technical quality. Westinghouse’s responses to our technical questions have made up for many of the gaps and shortfalls in the December 2009 PCSR, and a replacement PCSR was issued at the end of March 2011 (Reference 13). This will require assessment to confirm that it is fit for purpose. This has been identified as a GDA Issue.
- There are up to 1500 DCPs from Step 3 and Step 4 listed in the tables of the DR, many of which have not been fully incorporated into the design, safety and other engineering documentation. Our expectation is that Westinghouse will implement all the DCPs into the GDA submissions (i.e. the PCSR, MSL and DR). A formal process will be required to transfer any outstanding DCP information into the site-specific phase.

- The PCSR issued in March 2011 (Reference 13) will need to be reviewed by our assessors. In addition, the GDA submissions including PCSR, environmental reports, MSL and DR need to be updated to reflect progress in clearing the GDA Issues and incorporation of design changes. This has been identified as a GDA Issue.
- The correct setting of plant operating limits is key to both the prevention of situations which might lead to accident conditions, and the mitigation of the consequences of such accident conditions should they arise. The Westinghouse arrangements for defining limits and conditions important to safety were principally based on US regulatory requirements and there is not a clear derivation of the limits and conditions from the safety case analysis. Westinghouse needs to develop arrangements to advise a future operator of the AP1000 reactor of the limits and conditions that are important to safety, and clearly document how these are derived from the safety case. This has been identified as a GDA Issue.
- Our GDA guidance called for reactor designs submitted to us to be in metric units. The AP1000 reactor was conceived as an imperial unit design. We have discussed Westinghouse's plans for metrication of the AP1000 reactor for some time and, although significant progress has been made, we have not reached full agreement. The extent of non-metric items proposed, such as structural steelwork and mechanical fastenings, could have a significant impact on safety, particularly in respect of maintenance activities and construction. This has been identified as a GDA Issue under the Mechanical Engineering topic area.
- Safety classification and categorisation is an important element of the safety case as it allows a graded approach to safety, based on importance, and allows us to focus our assessment on those functions that are the most important. It also helps ensure that appropriate codes and standards are applied, according to the safety requirements for an SSC. Westinghouse has now recognised the UK requirements for SSC classification and is applying this to the AP1000 reactor. It now remains for the methodology to be cascaded through all necessary AP1000 reactor design and safety documentation. The main outstanding matters have been identified under a GDA Issue in the Structural Integrity topic area.
- On the SFP design, there are outstanding matters related to criticality, spent fuel cooling, containment and long-term storage of spent fuel. These have been identified as GDA Issues within the relevant topic areas.
  - Westinghouse's criticality safety case for the AP1000 reactor spent fuel pool relies on the presence of soluble boron to assure criticality safety during normal conditions. We have concluded that the proposed reliance on the presence of soluble boron to assure sub-criticality under normal conditions does not represent Relevant Good Practice (RGP). We believe that criticality control should instead be ensured via fuel rack geometry and fixed poisons.
  - In response to our assessment, Westinghouse has agreed to make modifications to improve the reliability of the fuel pool cooling systems. This needs to be developed into a new safety case that is incorporated into the PCSR and supporting documents.
  - There is a concern that leakage of borated water from the SFP could go undetected for a long period of time and could result in significant damage / contamination. We believe that a suitable second containment barrier with leak detection / collection is required to give the required redundancy for water containment.

- The design of the spent fuel storage facilities on the nuclear island should allow a licensee to address the needs of the long-term storage requirements so that spent fuel remains in a condition that would allow it to be transported for disposal. However, the size of the AP1000 reactor spent fuel pool may constrict the licensee's flexibility, on long-term storage and we will need to see further evidence of the degree of cooling necessary before fuel is placed into a dry store. This will be addressed in the Radioactive Waste and Decommissioning Assessment during the site-specific phase.

We have also asked Westinghouse to demonstrate how it will be taking account of the lessons learnt from the events at Fukushima, including from Westinghouse internal reviews and from those lessons and recommendations that are identified in HM Chief Inspector of Nuclear Installations' interim and final reports (References 10 and 11).

There are three GDA Issues in this topic area related to:

- Establishing arrangements to identify and advise the future licensee of the limits and conditions necessary in the interests of safety.
- Providing final consolidated versions of GDA submission documentation, including the PCSR, the environmental reports, MSL and DR document as the key references to any DAC we may issue at the end of GDA. (This has been identified as a joint GDA Issue with the Environment Agency, since the same requirements apply to any Statement of Design Acceptability it may issue.)
- To respond to the lessons learnt from the Fukushima accident, both from Westinghouse internal reviews and in response to HM Chief Inspector of Nuclear Installations' interim and final reports (References 10 and 11). (This has been identified as a joint GDA Issue with the Environment Agency.)

Demonstration of "as low as reasonably practicable"

Our assessment in Step 3 concluded that Westinghouse's approach to ALARP was satisfactory and was in line with our expectations for the GDA process (Annex 3 of Reference 18). At the time of our Step 3 public report, we anticipated that the focus of ALARP discussions for Step 4 would be within each of the individual topic areas and be primarily concerned with assessing Westinghouse's evidence justifying relevant good practices, or that those relevant good practices had been adequately implemented or followed. This has proven to be the case. In some topic areas, additional design changes have been made as a result of our assessment and these are discussed elsewhere in this report. In some topic areas, there are matters that remain under discussion: these we have identified as GDA Issues and their resolution could lead to some further design changes. In addition, the PSA assessment topic area looked across the whole design to see that risk was balanced, with an absence of "weak" areas, and an overall level of public risk that was consistent with the Basic Safety Objectives (BSO) given in our SAPs.

Our GDA guidance (Annex 3 of Reference 18) notes four key elements to the ALARP justification and a summary of the current position on these is given here:

- Westinghouse concludes that there are no further reasonably practicable measures that can be implemented. Overall, we accept the conclusion, subject to satisfactory resolution of GDA Issues and Assessment Findings. Future developments may identify new or enhanced standards that are judged reasonably practicable. Clearly, timescales and the status of the project when these new or enhanced standards arise will have an impact on reasonable practicability.

- The relevant good practices have been identified and summarised. Where our assessment does not fully concur we have identified GDA Issues for the more significant matters that need to be addressed before a final DAC can be issued, or GDA Assessment Findings where we are content that the matter can be satisfactorily dealt with on a site-specific basis. We will require all GDA Issues and Assessment Findings to be adequately addressed within GDA or as part of future site-specific activities as appropriate.
- It is clear that the development of the AP1000 reactor has considered a number of potential design options, seeking to build on, and improve, past Westinghouse designs. Further options for improvement have been considered and were deemed not reasonably practicable by Westinghouse. The conclusions were accepted, except in a small number of areas where our regulatory challenges in GDA have led to additional design changes. One example is the case of the civil structure modifications that Westinghouse proposed for the steel-concrete-steel composite structures including for the Enhanced Shield Building. In this particular instance it was not the ALARP process that was the issue, rather we disagreed with the methodology and assumptions regarding level of loading in the structure, and when acceptable engineering methodologies and assumptions were used the analysis clearly pointed to the need for strengthening.
- We noted that good use had been made of PSA during the design process and as part of the GDA interactions.

Our overall conclusion from our detailed assessment in Step 4 is that, subject to satisfactory resolution of the GDA Issues, within GDA, and the Assessment Findings, as part of future site-specific activities, the current AP1000 reactor design has reduced risks to workers and the public to ALARP.

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 4 OCNS, now ONR(CNS), has improved its understanding of the security philosophy applied to the Westinghouse AP1000 reactor design.

For GDA, our assessment included the following:

- Vital area identification and the related security measures (physical and electronic).
- Computer Based Systems Important to Nuclear Safety and the physical security of the associated equipment.
- Conceptual Security Arrangements (CSA) proposed by Westinghouse.

From our assessment, we have concluded:

- We are satisfied that the claims, arguments and evidence laid down within the conceptual security arrangements present an adequate security case for the generic AP1000 reactor design. From a security perspective the AP1000 reactor is therefore suitable for construction in the UK, although further development will be required by future site licensees during the site-specific phase.

There are no GDA Issues in this topic area.

Safeguards

Nuclear safeguards are measures to verify that states comply with their international obligations not to use nuclear materials (e.g. plutonium and 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 safeguards measures that apply in the UK follow from the NPT and also the requirements of the Euratom Treaty. They include the provision of nuclear material accountancy information combined with independent inspections by the European Commission (Euratom) and, in some instances, also the IAEA, to verify the facility design, the nuclear material inventory and associated records.

Safeguards are not a formal part of the GDA process but, as any new power reactors built in the UK will be subject to safeguards obligations, we have adopted an approach of early engagement with the reactor design companies. The basic approach to applying safeguards at modern PWRs is quite mature and implementation does not involve fundamental design challenges, but is instead a matter of ensuring arrangements for the necessary equipment installation (e.g. a limited number of safeguards cameras and seals, with associated cabling) are included in planning for reactor construction and commissioning. We followed our early engagement in GDA Step 3 with a briefing event in September 2010 that included Westinghouse and prospective reactor operators, where we and the Euratom safeguards inspectorate covered the safeguards reporting and verification arrangements necessary for reactors of the AP1000 type. Follow-up discussions are underway with prospective reactor operators and the Euratom safeguards inspectorate to confirm that these detailed safeguards requirements are included in plans going forward and this will be progressed as part of site-specific activities.

Conventional safety, construction and general fire precautions

As well as ONR’s role for regulating nuclear safety, HSE is responsible for regulating conventional safety, by which we mean normal industrial matters such as safety during construction, and fire safety and protection provisions. Conventional safety is not within the scope of GDA, nevertheless ONR, together with colleagues from HSE, have taken the opportunity to ensure that Westinghouse is fully aware of their responsibilities in these matters.

As well as the general requirements of the Health and Safety at Work etc. Act 1974 (HSWA74), particular attention has been given to early engagement with respect to both the application of the Construction (Design and Management) Regulations 2007 (CDM2007) and the Regulatory Reform (Fire Safety) Order 2005 relating to General Fire Precautions (GFP). This has included a combination of workshops and formal meetings. The potential impact CDM2007 and GFP could have on the overall project, should both aspects not be adequately addressed prior to the construction of any proposed facility, has been stressed.

While we are aware that Westinghouse is making progress, some further work is required in the treatment of GFP aspects. ONR has suggested that there may be benefit in dealing with this issue at the design stage by encompassing the control measures necessary during the construction phase, and ongoing maintenance, as well as during day-to-day operations. Westinghouse is currently reviewing its design codes to ensure they better reflect UK expectations and the approach to GFP, including the application of existing relevant good practice.

Westinghouse has attended a number of meetings and a specific GFP workshop arranged by ONR. However, it has yet to engage fully in addressing the needs of both CDM2007 and GFP.

We will engage with the various dutyholders (licensees, designers, contractors etc.) throughout the design and construction of the facility. The aim will be to satisfy ourselves that the project can be built safely, and can be used and maintained safely within the conventional non-nuclear meaning. We will do this by examination of policies and procedures, meetings with the dutyholders, and testing arrangements by inspection. Themes will include leadership for health and safety, competence of workers involved in the construction, and worker involvement in the management of health and safety on-site.

Western European Nuclear Regulators' Association

In 2008, the Western European Nuclear Regulators' Association (WENRA) published a set of reactor reference safety levels (Reference 19). Although these were intended primarily for operating nuclear reactors, we have considered these, where appropriate, in our assessment of the AP1000 reactor, as they are already covered within our SAPs and technical assessment guides, and form part of our guidance on the legal requirement to reduce risks *"so far as is reasonably practicable"* (SFAIRP).

Since then, WENRA has published two further documents:

- In 2009, a set of safety objectives for new power reactors (Reference 20), updated in November 2010. ONR was active in the development of these objectives and we consider them to be in line with our own SAPs, and therefore are included within GDA. As a result, we conclude that, once the GDA Issues have been dealt with, and the GDA Assessment Findings adequately addressed, the AP1000 will meet the WENRA safety objectives for new reactors.
- In 2011, a set of safety reference levels for waste and fuel pools (Reference 21). Again, we have reviewed the requirements of this document and have concluded that it would not have changed our Step 4 conclusions. This is because the reference levels for waste and spent fuel pools, in common with the reactor reference levels above, are already covered by our SAPs and technical assessment guides, and form part of our guidance on the legal requirement to reduce risks "so far as is reasonably practicable" (SFAIRP).

Issues raised through the public involvement process / stakeholder engagement

We recognise the importance of building public confidence in our ability to secure the protection of 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. These reports are available on the GDA website at: www.hse.gov.uk/newreactors.

During GDA Steps 2, 3 and 4, a total of 130 comments were received of which 64 were directed at the Requesting Parties and 66 at ONR. Of these, 65 related to the designs being assessed, 29 to the GDA process more generally, and 36 fell outside the scope of GDA.

The GDA website has continued to attract 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 eBulletins" 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 published 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 describe the technical issues we have raised against each of the designs we are assessing.

We also continue to speak at regional, national and international events, and have proactively organised seminars for key stakeholders.

For more information on the public involvement process for GDA Step 4 see *Update on the Public Involvement Process for GDA Step 4 of the Generic Design Assessment Process* (Reference 22).

Working with overseas regulators

Our strategy for working with overseas regulators during GDA is given on our website (see Reference 8). In accordance with this we have, throughout GDA, worked with overseas regulators, particularly with the Nuclear Regulatory Commission in the United States of America (US NRC) where the AP1000 reactor is also under active regulatory assessment. We have used these exchanges both to help our assessment (and theirs) during GDA Step 4 and to confirm that we are applying the best international standards.

This work has taken several forms in different topic areas:

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

Of particular benefit have been the information exchange meetings with our overseas counterparts on such topics as control and instrumentation and civil engineering.

In addition, we have participated in working group meetings of the Multinational 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. ONR represents the UK and takes a full part in the information sharing activities. In specific meetings related to the AP1000 reactor, discussion has included the following topics: civil engineering; control and instrumentation; control rod drive mechanisms; and squib valves.

A measure of our commitment to working with overseas regulators can be gauged by the fact that, overall, we had around 70 such information exchange meetings during Step 4. We have found these exchanges of information most valuable and we have taken account of them in the individual topic areas as appropriate.

Summary of main design changes that result from our assessment

In response to our assessment challenges, Westinghouse has made significant changes to the safety case for the AP1000 reactor and a number of design changes.

The AP1000 reactor design for GDA is based on a Design Reference Point (DRP) of 16 September 2010. Changes to the GDA Design reference (DR) since this date were subject to a change control procedure which requires agreement from the Regulators to include any design changes in GDA. However, a significant number of DCPs had been approved by Westinghouse prior to this date as part of the ongoing detailed design development. There are up to 1500 DCPs from Step 3 and Step 4 listed in the tables of the DR, many of which have not been fully incorporated into the design, safety and other engineering documentation. Our expectation for a final DAC is that Westinghouse will fully implement all the DCPs in the DR by incorporating the change details into all impacted DR documents, and the MSL documentation, including the PCSR.

In addition, after the DRP of 16 September 2010, Westinghouse formally requested that a number of other design changes be included. These arose from proposals from Westinghouse to improve the AP1000 reactor design, as a result of experience gained on other AP1000 projects, and as a result of our regulatory challenges. We accepted these for inclusion into GDA and they are included in Table 5 of the DR (Reference 16). Examples of design changes that originated from the regulators' interventions included:

- A battery room ventilation design change to reflect the need to maintain hydrogen concentrations below 1%, in line with BS 6133.
- A number of ventilation design changes to cover the introduction of HVAC HEPA filtration to the radioactive waste building exhaust and the fuel handling area exhaust systems.
- An increase in the exhaust vent stack height to meet UK expectations.
- Changes to the design of the SCS sandwich modular construction for the enhanced shield building, and other civil structural modules following the raising of our Regulatory Issue.
- Changes to the control and instrumentation including:

  - Improvements to the DAS to upgrade it from a 1-out-of-2 system to dual 1-out-of-2 system with elements of the architecture 2-out-of-3.
  - Modification to improve protection against SGTR faults.
  - Implementation of additional reactor trip signals.
  - Modification to reduce the risk of spurious ADS operation leading to depressurisation of the primary circuit.
  - Change of DAS technology from being based on complex FPGA to conventional electronics.
- Improvements to spent fuel pool cooling by changes to the residual heat removal system and the fire protection system.
- Changes to the classification of SSCs to reflect the difference in requirements between UK and US nuclear regulatory authorities.
- Changes to the primary sampling system.
- Separation of chemical and volume control system zinc acetate and hydrogen injection Paths.

There may, of course, be a requirement for further design changes prior to issue of any final DAC, depending on the responses to address the GDA Issues we have identified.

Summary of GDA Issues

We identified technical issues as early as possible in our assessment, and we discussed and progressed these with Westinghouse, and attempted to resolve them within Step 4. Westinghouse has worked hard to successfully close out many of the technical questions we raised. However, previous ONR 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, re-design, tests or research etc. to be carried out. Therefore, we always envisaged that there would be issues remaining at the end of Step 4.

In total there are 51 GDA Issues for the AP1000 reactor. These are described in the above technical sections and are listed in Annex 4. The full descriptions of the Issues and their associated "issue actions" were published on 14 July 2011 on our website: http://www.hse.gov.uk/newreactors. Further details on the background to the development of the GDA Issues is given in the topic area summaries, above, and in the detailed technical assessment reports listed in Annex 2.

When the GDA Issues have been addressed to our satisfaction, we will be in a position to consider issue of a final DAC. Until that time, no nuclear island safety-related construction of a power station based on the AP1000 reactor will be permitted.

Requesting Party resolution plans

In response to the GDA Issues, Westinghouse has provided detailed resolution plans that identify the details of how they intend to respond to the issues. We have reviewed these resolution plans and discussed them with Westinghouse and we agree that they are credible. A credible resolution plan is one that provides persuasive arguments that the work proposed will be sufficient to satisfactorily address the GDA Issue, in a timely manner, when considering the proposed scope of work, the deliverable descriptions, the timetable and milestone programme, the methodologies to be employed and the impact on the overall GDA submission documentation. A timely manner here refers to the duration of resolution plan itself, not to the predicted start or end dates.

It should be noted, however, that these resolution plans represent only one way of tackling each GDA Issue and Westinghouse may, in the end, choose another equally effective way of responding. Also, the resolution plans in no way represent a contract from ONR to complete assessment of GDA Issues within a particular programme, or to reach agreement on the matter.

Assessment Findings

The Assessment Findings arising from our GDA assessment for the AP1000 reactor are identified in the detailed Step 4 assessment reports for each technical topic area. In total there are 587 Assessment Findings for the AP1000 reactor.

The Assessment Findings provide the link from GDA to site-specific assessment for important safety items. They are primarily about ensuring the provision of additional safety case evidence to confirm certain safety aspects as the project progresses through the detailed design, construction and commissioning stages. For example, for some mechanical equipment, the safety functions and the specification of technical requirements were examined in GDA, but the evidence of fulfilment of those functions and requirements can only be demonstrated when the detail design of the equipment is completed and it has been tested, during the site specific phase.

Assessment Findings are also mostly matters that we would anyway have raised during our site-specific assessments. By identifying them now, we are maximising the time available for future licensees and operators of the AP1000 reactor to address them. Early identification of Assessment Findings in this way thus represents one of the key benefits of the GDA process.

After GDA, the Assessment Findings will be subject to appropriate control as part of normal regulatory oversight of new nuclear power station projects, and it will be the responsibility of the future operator / licensee to ensure they are addressed appropriately.

Conclusions

This is the third summary report on our GDA work for the AP1000 reactor and it summarises our findings at the end of GDA Step 4.

The aim of GDA Step 4 was to provide an overall detailed design assessment of each design submitted – in this case the AP1000 reactor – and, specifically, to:

- move from the system level assessment of Step 3 to a fully detailed examination of the evidence, on a sampling basis, given by the safety analyses;
- confirm that the higher level claims such as system functionality are properly justified; and
- complete sufficient, detailed, assessment to allow us to come to a judgement whether a DAC can be issued.

To achieve these aims, ONR has undertaken an in-depth assessment of the generic safety case. From a security perspective, we have examined the conceptual security arrangements.

For those assessment areas for which we only commenced work late during GDA Step 3, or for which insufficient information on the claims and arguments was available during that step, we have also completed work equivalent to the Step 3 overall design safety review.

Westinghouse's safety case for the AP1000 reactor was described in their December 2009 PCSR (Reference 12), which was submitted at the beginning of Step 4. In our assessment, we also used Westinghouse's responses to our regulatory questions to make up for many of the gaps and shortfalls in this PCSR. As a result, the PCSR was rewritten to take account of matters raised during our assessment, and to improve the presentation and coherence of the safety arguments, and the final updated version was submitted on 30 March 2011 (Reference 13). Although this was too late to allow assessment within Step 4, this will be progressed in the related GDA Issue.

We have undertaken a large volume of work and we have completed our planned assessment of the AP1000 reactor. Westinghouse has worked hard to close out many of the technical questions we raised, and we have judged many aspects to be acceptable and our assessment work in these areas is complete. We are thus confident that we have completed a meaningful assessment of the AP1000 reactor.

Nevertheless, we have identified 51 GDA Issues for the AP1000 reactor, which we require to be addressed before we would consider issue of a DAC, or allow any safety-related nuclear island construction to begin for a power station based on an AP1000 reactor design. Some of these Issues may be resolved with additional safety case changes while others may require design changes. We will summarise our progress on these in our quarterly progress reports, which we will continue to place on our website. We will also update the GDA Issues pages on our website as each GDA Issue is closed.

The scope of the Step 4 technical assessment reports did not include Fukushima as the accident occurred after the Step 4 submissions were provided to us. However, we have ensured that we will address the lessons from Fukushima by including this as a specific GDA Issue.

Westinghouse has produced a resolution plan for each of the GDA Issues, including the issue to address the lessons learnt from Fukushima. We have reviewed these and judged them to be credible.

We have therefore concluded that we are largely satisfied with the design and safety case that has been presented to us by Westinghouse for the AP1000 reactor.

In recognition of this we have decided to issue an interim DAC.

The interim DAC does not in itself permit any additional action in terms of nuclear power station construction, but it does signify that a major milestone has been achieved in that we have reached the end of our planned assessment. It also means that our further assessment work will be targeted on the remaining GDA Issues that will be progressed in accordance with the resolution plans that Westinghouse has provided to us.

Once the work identified in the GDA Issues has been addressed satisfactorily, then we should be in a position to consider issue of a final DAC, which will be supported by a report of our assessment.

By completing a comprehensive, robust and independent assessment and raising the GDA Issues and the Assessment Findings well ahead of any AP1000 reactor construction, we believe that we have met the key objectives of the GDA process.

Annex 1: Key GDA milestones

January 2007

HSE and EA publish guidance on the GDA process.

July 2007

Four companies make valid applications for GDA:

- EDF and AREVA – UK EPR™ reactor
- Westinghouse Electric Company LLC – AP1000 reactor
- GE-Hitachi Nuclear Energy – ESBWR reactor
- Atomic Energy of Canada Limited – ACR-1000 reactor

July 2007

GDA process launched (Step 1).

September 2007

Initial assessment of the designs begins (Step 2).

March 2008

HSE and the Environment Agency announce that their initial assessment of four new nuclear power station designs found no shortfalls at this stage.

April 2008

Atomic Energy of Canada Ltd announces that it is withdrawing its ACR-1000 design from the assessment process.

June 2008

HSE and the Environment Agency announce that they are starting the next, more detailed stage of the assessment process for the remaining three designs (Step 3).

September 2008

GE-Hitachi requests a temporary suspension from GDA. As a result, both Regulators suspend assessment work on the ESBWR reactor.

May 2009

HSE and the Environment Agency publish their first quarterly report for 2009 (January–March), which provides an update on their assessment work. This is the first of a series of regular updates to be produced.

July 2009

HSE and the Environment Agency publish their second quarterly report for 2009 (April–June). This provides an update on their work to assess new nuclear power station designs.

October 2009

HSE and the Environment Agency publish their third quarterly report for 2009 (July–September). This provides an update on their work to assess new nuclear power station designs.

November 2009

HSE publishes Step 3 reports. The detailed Step 4 assessment begins.

February 2010

HSE and the Environment Agency publish their fourth quarterly report for 2009 (October–December). This provides an update on their work to assess new nuclear power station designs.

April 2010

HSE and the Environment Agency publish their first quarterly report for 2010 (January–March). This provides an update on their work to assess new nuclear power station designs.

May 2010

Environment Agency begins a public consultation, running until September 2010, to help inform its decision on the designs.

June 2010

HSE and the Environment Agency publish guidance on “Management of GDA outcomes”. This guidance sets out the outcomes that can be expected in June 2011, when we were expecting to complete our assessment of the safety cases of both the designs. It also simplifies and makes clear what these outcomes mean and how any outstanding GDA Issues will be managed subsequently within the GDA process.

July 2010

HSE and the Environment Agency publish their second quarterly report for 2010 (April–June). This provides an update on their work to assess new nuclear power station designs.

October 2010

HSE and the Environment Agency publish their third quarterly report for 2010 (July–September). This provides an update on their work to assess new nuclear power station designs.

January 2011

HSE and the Environment Agency publish their fourth quarterly report for 2010 (October–December). This provides an update on their work to assess new nuclear power station designs.

March 2011

On 11 March 2011 an earthquake and tsunami inundate the Fukushima-1 site in Japan, resulting in massive damage around the site and loss of cooling systems for Reactor Units 1 to 3. There are several explosions and what is predicted to be melting of the fuel in the reactors leading to major releases of radioactivity, initially to air but later by leakage of contaminated water to sea.

On 14 March 2011 the Secretary of State for Energy and Climate Change requested HM Chief Inspector of Nuclear Installations to examine the circumstances of the Fukushima accident to see what lessons could be learnt to enhance the safety of the UK nuclear industry. He requested an interim report to be provided by the middle of May 2011 and a final report within six months.

It is decided to delay drawing conclusions from GDA until the lessons learnt from Fukushima emerge.

April 2011

HSE and the Environment Agency publish their first quarterly report for 2011 (January–March). This provides an update on their work to assess new nuclear power station designs and looks at the likely implications for GDA following the events at Fukushima.

May 2011

HM Chief Inspector of Nuclear Installations publishes his interim report on the lessons learnt from the Fukushima accident in Japan.

July 2011

HSE and the Environment Agency publish their second quarterly report for 2011 (April–June), identifying and listing the GDA Issues, which are also published on the GDA website. The Requesting Parties resolutions plans, with the exception of the resolution plan for identifying and applying the lessons learnt from the Fukushima accident, are also published.

October 2011

HSE and the Environment Agency publish their third quarterly report for 2011 (July–September). HM Chief Inspector of Nuclear Installations publishes his final report on the lessons learnt from the Fukushima accident in Japan.

October–November 2011

Requesting Parties submit resolution plans for the Fukushima lessons learnt GDA Issue.

December 2011

ONR publishes Step 4 summary, assessment and other reports which set out its findings and conclusions of the assessment. ONR also issues an interim DAC for the Westinghouse AP1000 reactor.

Annex 2: Generic Design Assessment published reports

GDA Step 2 reports

Public summary report

Public Report on the Generic Design Assessment of New Reactor Designs. Westinghouse Electric Company LLC AP1000 Reactor. Conclusions of the fundamental safety overview of the AP1000 Nuclear Reactor (Step 2 of the Generic Design Assessment process) HSE-GDA/004 March 2008 www.hse.gov.uk/newreactors/reports/ap1000public.pdf

Assessment reports

Westinghouse AP1000 Step 2 ALARP Assessment HSE Nuclear Directorate Division 6 Assessment Report AR 08/014 March 2008

Westinghouse Step 2 C&I Assessment HSE Nuclear Directorate Division 6 Assessment Report AR 07/004 March 2008

Step 2 Westinghouse–AP1000 Civil Engineering and External Hazard Assessment HSE Nuclear Directorate Division 6 Assessment Report AR 07/008 March 2008

Step 2 Fault Analysis Assessment of the Westinghouse Submission for the AP1000 HSE Nuclear Directorate Division 6 Assessment Report AR 07/016 March 2008

Step 2 Westinghouse–AP1000 Internal Hazard Assessment HSE Nuclear Directorate Division 6 Assessment Report AR 07/012 March 2008

Westinghouse AP1000 Step 2 PSA Assessment HSE Nuclear Directorate Division 6 Assessment Report AR 08/009 March 2008

Step 2 – Preliminary Review Assessment of Structural Integrity Aspects of Westinghouse AP1000 HSE Nuclear Directorate Division 6 Assessment Report AR 08/005 March 2008

The above reports are available on the GDA website at: www.hse.gov.uk/newreactors

Other reports

IAEA Generic Review for UK HSE of New Reactor Designs against IAEA Safety Standards IAEA Nuclear Installation Safety Division Review Summary Report HSE March 2008 www.hse.gov.uk/newreactors/reports/iaeasummary.pdf

New Reactor Build. GDA Step 2 Summary of Overseas Regulatory Assessments HSE Nuclear Directorate Assessment Report March 2008 www.hse.gov.uk/newreactors/reports/overseas.pdf

Report on the Joint Regulators' Team Inspection of Westinghouse's Arrangements as part of the Generic Design Assessment (Quality Management Arrangements) March–April 2009 HSE Joint Programme Office www.hse.gov.uk/newreactors/reports/wec-inspection-report-2009.pdf

Description and outcome of the public involvement process carried out on behalf of the Health and Safety Executive and the Environment Agency during the initial assessment of the: AREVA NP SAS and Electricité de France SA UK EPR™ Nuclear Reactor; Atomic Energy of Canada Limited ACR-1000 Nuclear Reactor; GE-Hitachi Nuclear Energy International LLC ESBWR Nuclear Reactor; Westinghouse Electric Company LLC AP1000 Nuclear Reactor HSE March 2008 www.hse.gov.uk/newreactors/reports/publicinvolvment.pdf

GDA Step 3 reports

Summary report

Public Report on the Generic Design Assessment of New Reactor Designs. Westinghouse Electric Company LLC AP1000 Nuclear Reactor. Report of the system design and security review of the AP1000 Nuclear Reactor June 2009–October 2009 (Step 3 of the Generic Design Assessment process) HSE-GDA/005 November 2009 www.hse.gov.uk/newreactors/reports/step3-westinghouse-public-report-gda.pdf

Assessment reports

Step 3 Internal Hazards Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/016 November 2009

Step 3 Civil Engineering and External Hazards Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/034 November 2009

Step 3 Probabilistic Safety Analysis Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/017 November 2009

Step 3 Fault Studies Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/018 November 2009

Step 3 Control and Instrumentation Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/037 November 2009

Step 3 Electrical Systems Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/019 November 2009

Step 3 Fuel Design Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/040 November 2009

Step 3 Reactor Chemistry Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/035 January 2010

Step 3 Radiological and Level 3 PSA Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/020 November 2009

Step 3 Mechanical Engineering Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/015 November 2009

Step 3 Structural Integrity Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/013 November 2009

Step 3 Human Factors Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/021 November 2009

Step 3 Management of Safety and Quality Assurance Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/022 November 2009

Step 3 Radioactive Waste and Decommissioning Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/023 November 2009

Step 3 Security Assessment of the Westinghouse AP1000 HSE-ND Assessment Report AR 09/042 October 2009

The above reports are available on the GDA website at: www.hse.gov.uk/newreactors

Other reports

Public Report on the Generic Design Assessment of New Nuclear Reactor Designs Update on the Public Involvement Process for Step 3 of the Generic Design Assessment Process November 2009 www.hse.gov.uk/newreactors/reports/step3-public-report-gda-new-nuclear-reactor-designs.pdf

GDA Step 4 reports

Summary report

New nuclear reactors: Generic Design Assessment. Westinghouse Electric Company LLC AP1000® nuclear reactor. Summary of the detailed design assessment of the AP1000® nuclear reactor (Step 4 of the Generic Design Assessment Process) ONR-GDA-SR-002 Revision 0 December 2011 Available via website www.hse.gov.uk/newreactors

Assessment reports

Step 4 Cross-cutting Topics Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-016, Revision 0

Step 4 Internal Hazards Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-001, Revision 0

Step 4 Civil Engineering and External Hazards Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-002, Revision 0

Step 4 Probabilistic Safety Analysis Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-003, Revision 0

Step 4 Fault Studies – Design Basis Faults Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-004a, Revision 0

Step 4 Fault Studies – Containment and Severe Accident Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-004b, Revision 0

Step 4 Control and Instrumentation Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-006, Revision 0

Step 4 Electrical Systems Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-007, Revision 0

Step 4 Fuel and Core Design Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-005, Revision 0

Step 4 Reactor Chemistry Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-008, Revision 0

Step 4 Radiological Protection Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-009, Revision 0

Step 4 Mechanical Engineering Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-010, Revision 0

Step 4 Structural Integrity Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-011, Revision 0

Step 4 Human Factors Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-012, Revision 0

Step 4 Management of Safety and Quality Assurance Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-013, Revision 0

Step 4 Radioactive Waste and Decommissioning Assessment of the Westinghouse AP1000® Reactor ONR Assessment Report ONR-GDA-AR-11-014, Revision 0

Step 4 Security Assessment *of the Westinghouse AP1000® Reactor* ONR Assessment Report ONR-GDA-AR-11-015, Revision 0

The above reports are available on the GDA website at: www.hse.gov.uk/newreactors

Other reports

New nuclear reactors: Generic Design Assessment. Update on the Public Involvement Process for GDA Step 4 of the Generic Design Assessment Process ONR-GDA-SR-11-003 Revision 0 December 2011. Available via website www.hse.gov.uk/newreactors

Annex 3: Summary of HSE expectations for the GDA process

HSE expectations for Step 2 of the GDA process

Details of HSE's expectations for Step 2 of the GDA process can be found in the GDA guidance (Reference 2). From that document, the key expectations of Requesting Parties for Step 2 are:

Provide a Preliminary Safety Report that includes sufficient information for the Step 2 Fundamental Safety Overview, in particular:

1. *A statement of the design philosophy and a description of the resultant conceptual design sufficient to allow identification of the main nuclear safety hazards, control measures and protection systems.*
2. *A description of the process being adopted by the applicant to demonstrate compliance with the UK legal duty to reduce risks to workers and the public so far as is reasonably practicable (SFAIRP).*
3. *Details of the safety principles and criteria that have been applied by the Requesting Party in its own assessment processes, including risks to workers and the public.*
4. *A broad demonstration that the principles and criteria are likely to be achieved.*
5. *An overview statement of the approach, scope, criteria and output of the deterministic safety analyses.*
6. *An overview statement of the approach, scope, criteria and output of the probabilistic safety analyses.*
7. *Specification of the site characteristics to be used as the basis for the safety analysis (the 'generic siting envelope').*
8. *Explicit references to standards and design codes used, justification of their applicability and a broad demonstration that they have been met (or exceptions justified).*
9. *Information on the quality management arrangements for the design, including design controls; control of standards; verification and validation; and interface between design and safety.*
10. *A statement giving details of the safety case development process, including peer review arrangements, and how this gives assurance that nuclear risks are identified and managed.*
11. *Information on the quality management system for the safety case production.*
12. *Identification and explanation of any novel features, including their importance to safety.*
13. *Identification and explanation of any deviations from modern international good practices.*

14. *Sufficient detail for HSE to satisfy itself that HSE's Safety Assessment Principles (SAPs) and that the Western European Nuclear Regulators' Association (WENRA) Reference Levels are likely to be satisfied.*
15. *Where appropriate, information about all the assessments completed by overseas regulators.*
16. *Identification of outstanding information that remains to be developed and its significance.*
17. *Information about any long lead items that may be manufactured in parallel with the Design Acceptance process.*
18. *Information on radioactive waste management and decommissioning. The Requesting Party will also be required to respond to questions and points of clarification raised by HSE during its assessment, and to issues arising from public comments.*

HSE expectations for Step 3 of the GDA process

Details of HSE expectations for Step 3 of the GDA process can be found in the GDA guidance (Reference 2). From that document, the key expectations of Requesting Parties for GDA Step 3 are:

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.*

HSE expectations for Step 4 of the GDA process

Details of HSE expectations for Step 4 of the GDA process can be found in the GDA guidance (Reference 2). From that document, the key expectations of Requesting Parties for GDA Step 4 are:

Provide any outstanding information, safety case material and research results that support the [Step 3] submission and, in addition, to submit:

1. *A demonstration that construction and installation activities will result in a Plant of appropriate quality.*
2. *A demonstration that the constructed Plant will be capable of being operated within safe limits.*
3. *Arrangements for moving the safety case to an operating regime, ie the arrangements to ensure that the requirements of, and assumptions in, the safety case will be captured in:*
    - *(a) technical specifications*
    - *(b) maintenance schedule*
    - *(c) procedures (normal operation, emergency, accident management);*
    - *(d) training programmes;*
    - *(e) emergency preparedness;*
    - *(f) operating limits;*
    - *(g) radiation protection arrangements for operators;*
    - *(h) lifetime records;*
    - *(i) commissioning requirements etc.*
4. *Arrangements for design and safety case definition and freeze.*
5. *Arrangements for putting in place a design authority.*

6. *Arrangements that demonstrate that any site-specific changes against the generic design will be managed within an agreed control process.*
7. *Responses to any Issues outstanding from Step 3.*

Annex 4: Westinghouse AP1000 Reactor GDA Issues and resolution plans

GDA Issue	GDA Issue Reference	Resolution Plan Reference
Internal Hazards		
Internal Fire Safety Case Substantiation	GI-AP1000-IH-01 GDA Issue, Revision 0	GI-AP1000-IH-01 Resolution Plan, Revision 3
Internal Flooding Safety Case	GI-AP1000-IH-02 GDA Issue, Revision 0	GI-AP1000-IH-02 Resolution Plan, Revision 5
Pressure Part Failure	GI-AP1000-IH-03 GDA Issue, Revision 0	GI-AP1000-IH-03 Resolution Plan, Revision 4
Internal Explosion Safety Case Substantiation	GI-AP1000-IH-04 GDA Issue, Revision 0	GI-AP1000-IH-04 Resolution Plan, Revision 3
Internal Missile Safety Case	GI-AP1000-IH-05 GDA Issue, Revision 0	GI-AP1000-IH-05 Resolution Plan, Revision 6
Substantiation and Analysis of the Consequences of Dropped Loads and Impact from Lifting Equipment Included Within the AP1000 Design	GI-AP1000-IH-06 GDA Issue, Revision 0	GI-AP1000-IH-06 Resolution Plan, Revision 2
Civil Engineering		
Justification of Novel Form of Structure for the Steel / Concrete Composite Walls and Floors Known as CA Modules	GI-AP1000-CE-01 GDA Issue, Revision 0	GI-AP1000-CE-01 Resolution Plan, Revision 2
Further Justification of Novel Form of Structure for Steel / Concrete Composite Wall to the Enhanced Shield Building	GI-AP1000-CE-02 GDA Issue, Revision 1	GI-AP1000-CE-02 Resolution Plan, Revision 3
AP1000 Material Standards and Material Specifications	GI-AP1000-CE-03 GDA Issue, Revision 0	GI-AP1000-CE-03 Resolution Plan, Revision 2
Fuel Handling Area – Secondary Containment Leak Detection and Collection System	GI-AP1000-CE-04 GDA Issue, Revision 0	GI-AP1000-CE-04 Resolution Plan, Revision 4
Probabilistic Safety Analysis (PSA)		
Success Criteria for the PSA	GI-AP1000-PSA-01 GDA Issue, Revision 0	GI-AP1000-PSA-01 Resolution Plan, Revision 1
Fire PSA	GI-AP1000-PSA-02 GDA Issue, Revision 0	GI-AP1000-PSA-02 Resolution Plan, Revision 1

GDA Issue	GDA Issue Reference	Resolution Plan Reference
Fault Studies		
Spent Fuel Pool Safety Case	GI-AP1000-FS-01 GDA Issue, Revision 0	GI-AP1000-FS-01 Resolution Plan, Revision 2
Design Reference Point and Adequacy of Design Basis Analysis	GI-AP1000-FS-02 GDA Issue, Revision 0	GI-AP1000-FS-02 Resolution Plan, Revision 1
Diversity for Frequent Faults	GI-AP1000-FS-03 GDA Issue, Revision 0	GI-AP1000-FS-03Resolution Plan, Revision 1
Use of In-core Detectors to Protect Against Adverse Power Distributions	GI-AP1000-FS-04 GDA Issue, Revision 0	GI-AP1000-FS-04 Resolution Plan, Revision 2
Potential Enhancements to the Diverse Safety Injection System	GI-AP1000-FS-05 GDA Issue, Revision 1	GI-AP1000-FS-05 Resolution Plan, Revision 2
Validation of the IRWST Cooling Function for the PRHR	GI-AP1000-FS-06 GDA Issue, Revision 0	GI-AP1000-FS-06 Resolution Plan, Revision 1
Safety Case for Shutdown Faults	GI-AP1000-FS-07 GDA Issue, Revision 0	GI-AP1000-FS-07 Resolution Plan, Revision 1
Fault Schedule for AP1000	GI-AP1000-FS-08 GDA Issue, Revision 0	GI-AP1000-FS-08 Resolution Plan, Revision 1
Control & Instrumentation		
Adequacy of Safety Case for DAS	GI-AP1000-CI-01 GDA Issue, Revision 0	GI-AP1000-CI-01 Resolution Plan, Revision 1
DAS – Adequacy of Architecture	GI-AP1000-CI-02 GDA Issue, Revision 0	GI-AP1000-CI-02 Resolution Plan, Revision 1
Diversity Between the PMS (CIM) and DAS	GI-AP1000-CI-03 GDA Issue, Revision 0	GI-AP1000-CI-03 Resolution Plan, Revision 2
PMS Spurious Operation	GI-AP1000-CI-04 GDA Issue, Revision 0	GI-AP1000-CI-04 Resolution Plan, Revision 1
SMART Device Justification for Use	GI-AP1000-CI-05 GDA Issue, Revision 0	GI-AP1000-CI-05 Resolution Plan, Revision 2
Ovation Platform – Adequacy of Safety Case	GI-AP1000-CI-06 GDA Issue, Revision 0	GI-AP1000-CI-06 Resolution Plan, Revision 3
DCIS – Adequacy of Safety Case	GI-AP1000-CI-07 GDA Issue, Revision 0	GI-AP1000-CI-07 Resolution Plan, Revision 3
PMS – Adequacy of Safety Case	GI-AP1000-CI-08 GDA Issue, Revision 0	GI-AP1000-CI-08 Resolution Plan, Revision 1
CIM – Adequacy of Safety Case	GI-AP1000-CI-09 GDA Issue, Revision 0	GI-AP1000-CI-09 Resolution Plan, Revision 1
Class 1 Displays and Controls	GI-AP1000-CI-010 GDA Issue, Revision 0	GI-AP1000-CI-010 Resolution Plan, Revision 1

GDA Issue	GDA Issue Reference	Resolution Plan Reference
Essential Electrical Systems		
Pre-construction Safety Report Presentation of Claims Arguments and Evidence	GI-AP1000-EE-01 GDA Issue, Revision 0	GI-AP1000-EE-01 Resolution Plan, Revision 2
Fuel Design		
Fuel Pin Modelling Safety Justification	GI-AP1000-FD-01 GDA Issue, Revision 0	GI-AP1000-FD-01 Resolution Plan, Revision 1
Tolerability of Depressurisation Forces in LBLOCA	GI-AP1000-FD-02 GDA Issue, Revision 0	GI-AP1000-FD-02 Resolution Plan, Revision 1
Use of the BEACON Code for On-line Compliance	GI-AP1000-FD-03 GDA Issue, Revision 0	GI-AP1000-FD-03 Resolution Plan, Revision 1
Reactor Chemistry		
Accident Source Terms	GI-AP1000-RC-01 GDA Issue, Revision 0	GI-AP1000-RC-01 Resolution Plan, Revision 2
Primary Sampling System	GI-AP1000-RC-02 GDA Issue, Revision 0	GI-AP1000-RC-02Resolution Plan, Revision 2
Hydrogen Dosing System	GI-AP1000-RC-03 GDA Issue, Revision 0	GI-AP1000-RC-03 Resolution Plan, Revision 1
Radiation Protection		
Spent Fuel Pool – Criticality Safety Case	GI-AP1000-RP-01 GDA Issue, Revision 0	GI-AP1000-RP-01 Resolution Plan, Revision 2
Mechanical Engineering		
Squib Valve Concept and Design Substantiation	GI-AP1000-ME-01 GDA Issue, Revision 1	GI-AP1000-ME-01 Resolution Plan, Revision 2
Metrication of Mechanical Equipment and Civil Structural Steelwork Connections	GI-AP1000-ME-02 GDA Issue, Revision 1	GI-AP1000-ME-02 Resolution Plan, Revision 1
Mechanical System Pipework Design	GI-AP1000-ME-03 GDA Issue, Revision 0	GI-AP1000-ME-03 Resolution Plan, Revision 2
Structural Integrity		
Avoidance of Fracture	GI-AP1000-SI-01 GDA Issue, Revision 0	GI-AP1000-SI-01 Resolution Plan, Revision 2

GDA Issue	GDA Issue Reference	Resolution Plan Reference
Fatigue Analysis	GI-AP1000-SI-02 GDA Issue, Revision 0	GI-AP1000-SI-02 Resolution Plan, Revision 1
Reactor Coolant Pump	GI-AP1000-SI-03 GDA Issue, Revision 0	GI-AP1000-SI-03 Resolution Plan, Revision 1
Containment Vessel	GI-AP1000-SI-04 GDA Issue, Revision 0	GI-AP1000-SI-04 Resolution Plan, Revision 5
Compliance of AP1000 Main Structural Components with ASME III Design Rules	GI-AP1000-SI-05 GDA Issue, Revision 0	GI-AP1000-SI-05 Resolution Plan, Revision 2
Categorisation and Classification	GI-AP1000-SI-06 GDA Issue, Revision 0	GI-AP1000-SI-06 Resolution Plan, Revision 2
Human Factors		
Completeness of the Human Factors Safety Case	GI-AP1000-HF-01 GDA Issue, Revision 0	GI-AP1000-HF-01 Resolution Plan, Revision 1
Cross-cutting Topics		
Limits and Conditions	GI-AP1000-CC-01 GDA Issue, Revision 0	GI-AP1000-CC-01 Resolution Plan, Revision 3
Pre-construction Safety Report to Support GDA	GI-AP1000-CC-02 GDA Issue, Revision 3	GI-AP1000-CC-02 Resolution Plan, Revision 2
Consider and Action Plans to Address the Lessons Learnt from the Fukushima Event	GI-AP1000-CC-03 GDA Issue, Revision 2	GI-AP1000-CC-03 Resolution Plan, Revision 1

The GDA Issues and Westinghouse's resolution plans are available on the GDA website at: www.hse.gov.uk/newreactors.

References

1 *New nuclear power stations. Generic Design Assessment. Guidance on the management of GDA outcomes* Version 1 June 2010 HSE www.hse.gov.uk/newreactors/reports/management-gda-outcomes.pdf

2 *Nuclear* power *station generic design assessment – guidance to requesting parties* (Version 3) HSE August 2008 www.hse.gov.uk/newreactors/ngn03.pdf

3 *Guidance document for generic design assessment activities* (Version 2) Office for Civil Nuclear Security 201206 January 2007 www.hse.gov.uk/nuclear/ocns/ocnsdesign.pdf

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

5 *Safety* assessment *principles for nuclear facilities* (2006 Edition Version 1) HSE December 2006 www.hse.gov.uk/nuclear/saps/saps2006.pdf [2.8MB]

6 *New nuclear power stations. Generic Design Assessment. Guide to the regulatory processes* Version 2 August 2008 HSE and Environment Agency www.hse.gov.uk/newreactors/ngn01.pdf

7 *New nuclear power stations. Generic Design Assessment. Safety assessment in an international context* Version 3 March 2009 HSE www.hse.gov.uk/newreactors/ngn05.pdf

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9 *Paper on the required level of design waste plants for new build reactors in the Generic Design Assessment* HSE Nuclear Directorate 19 May 2009 www.hse.gov.uk/newreactors/wasteplants.pdf

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While every effort has been made to ensure the accuracy of the references listed in this report, their future availability cannot be guaranteed.

Glossary and Abbreviations

AC	Alternating Current
ADS	Automatic Depressurisation System
AECL	Atomic Energy of Canada Limited
ALARP	As low as reasonably practicable
AVR	Automatic Voltage Regulator
BSO	Basic Safety Objective (In SAPs)
C&I	Control and Instrumentation
CBSIS	Computer Based Systems Important to Nuclear Safety
CDM2007	Construction (Design and Management) Regulations 2007
CHF	Critical Heat Flux
CIM	Component Interface Module
CNS	Convention on Nuclear Safety
CNS	Civil Nuclear Security (part or ONR)
CRUD	Crystalline material (usually oxides) deposited on a heat transfer surface, increasing its roughness and, in some cases, introducing a resistance to heat transfer.
CSA	Conceptual Security Arrangements
CVS	Volume Control System
DAC	Design Acceptance Confirmation
DAS	Diverse Actuation System
DC	Direct Current
DCIS	Distributed Control and Information System
DCP	Design Change Proposal
DECC	Department of Energy and Climate Change
DfT	Department for Transport
DR	Design Reference
DRP	Design Reference Point
DTI	Department of Trade and Industry (now DECC)
EDF	Electricité de France
EDI	Electrodeionisation
ENSREG	European Nuclear Safety Regulatory Group
EPR10	Environmental Permitting Regulations 2010
EPRI	Electric Power Research Institute (United States of America)
FPGA	Field programmable Gate Array
GDA	Generic Design Assessment
HEPA	High Efficiency Particulate Air

HFE	Human Factors Engineering
HFI	Human Factors Integration
HI	High Integrity
HRA	Human Reliability Assessment
HSE	Health and Safety Executive
HSS	Highest Safety Significance
HSWA74	Health and Safety at Work etc. Act 1974, as amended
IAEA	International Atomic Energy Agency
IEC	International Electrotechnical Commission
IEC	International Electrotechnical Committee
ILW	Intermediate level waste
IRR99	Ionising Radiations Regulations 1999
IRWST	In-containment Refuelling Water Storage Tank
IVR	In-vessel Retention
LLW	Low level waste
LOCA	Loss of Coolant Accident
MDEP	Multinational Design Evaluation Programme
MOS	Management of Safety
MOX	Mixed-oxide Fuel
MSL	Master Submission List
MSQA	Management of Safety and Quality Assurance
ND	Nuclear Directorate (of the Health and Safety Executive, now the Office for Nuclear Regulation)
NI	Nuclear Island
NPT	Non-proliferation Treaty
OCNS	Office for Civil Nuclear Security (now Civil Nuclear Security, part of the Office for Nuclear Regulation)
OJEU	Official Journal of the European Union
ONR	Office for Nuclear Regulation (formerly the Nuclear Directorate of the Health and Safety Executive)
ONR(CNS)	Civil Nuclear Security (part of the Office for Nuclear Regulation)
PAR	Passive Autocatalytic Recombiners
PCI	Pellet Clad Interaction
PCSR	Pre-construction Safety Report
PLS	Plant Control System
PMS	Plant Monitoring System
PRA	Probabilistic Risk Analysis

PRHR	Passive Residual Heat Removal
PSA	Probabilistic Safety Analysis
PSR	Preliminary Safety Report
PUWER1998	Provision and Use of Work Equipment Regulations 1998
PWR	Pressurised Water Reactor
PXS	Containment Cooling System
QA	Quality Assurance
REPPIR2001	Radiation (Emergency Preparedness and Public Information) Regulations 2001
RGA	Risk Gap Analysis
RGP	Relevant Good Practice
RPV	Reactor Pressure Vessel
SAP	Safety Assessment Principles
SCS	Steel-concrete-steel
SF	Safety Function
SFAIRP	So far as is reasonably practicable
SFP	Spent Fuel Pond
SGTR	Steam Generator Tube Rupture
SIS	System Important to Safety
SSC	Structures, Systems and Components
STUK	Säteilyturvakeskus (the Finnish Nuclear Safety Authority)
TSC	Technical Support Contractor
US NRC	United States Nuclear Regulatory Commission
WENRA	Western European Nuclear Regulators' Association

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